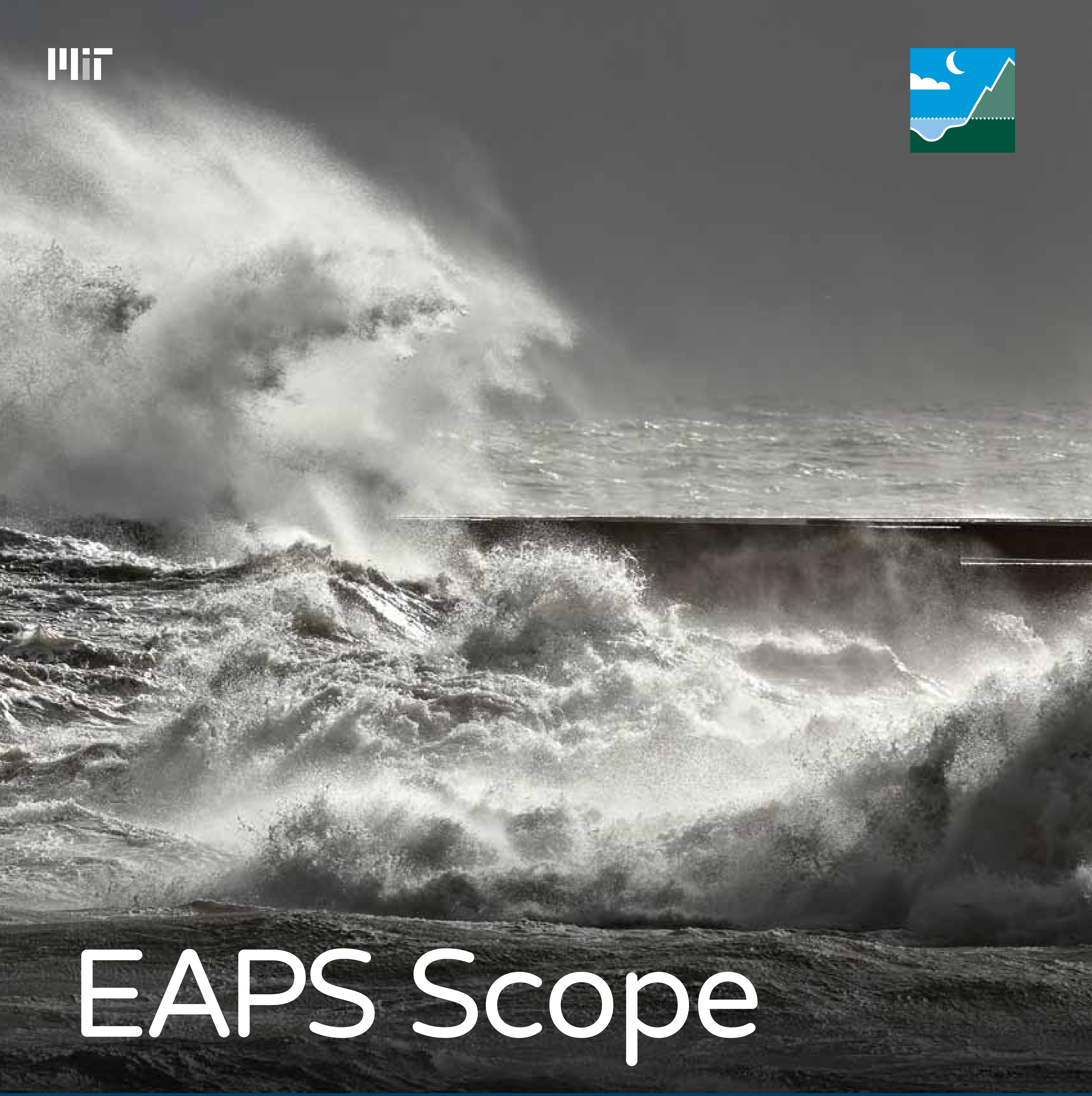

EAPS Scope

NEWSLETTER OF THE DEPARTMENT OF EARTH, ATMOSPHERIC AND PLANETARY SCIENCES | 2015-2016

THE

Climate Issue

As a global leader in climate science EAPS is unique in its interdisciplinary approach. This issue of EAPS Scope is packed with stories about how our broad range of research and collaboration are helping us gain a deeper understanding of the history and future of climates—from here on earth to planets far, far away.

News

PAGE 7

Sam Bowring and Sara Seager elected to the National Academy of Sciences • Faculty promotions • Clark Burchfiel retires • Introducing Assistant Professor Kristin Bergmann • Recent faculty honors • Research in the spotlight • Graduate student profiles • Degrees Awarded in 2014-2015

Friends

PAGE 28

Read about past and future EAPS lectures and events • Two new fellowships and a professorship announced • Donor Profiles • The first annual Patrons Circle event • Exciting travel opportunities with our faculty • Find out how you can help us to continue to attract the best and the brightest to EAPS

EAPS Scope is published annually by the MIT Department of Earth, Atmospheric and Planetary Sciences. We welcome your news and comments. Please send correspondence to: ***eapsnewsletter@mit.edu***

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LETTER FROM THE DEPARTMENT HEAD

Dear Alumni and Friends,

Attention has been riveted on Pluto since the New Horizons mission began beaming back those first startling images of the icy dwarf planet at the edge of our solar system. It made us all very proud to see EAPS alumnae, faculty, and students on NASA TV, the news, and on the internet this summer, and to reflect on EAPS scientists' role in this historic mission. We're especially mindful of the contribution of the late Jim Elliot, professor of planetary science and physics at MIT, who discovered Pluto's atmosphere. A number of Jim's former graduate students, including Cathy Olkin '88, PhD '96 and Leslie Young, PhD '94, are now playing leading roles in the New Horizons mission. I am delighted to report that, in recognition of Jim's legacy as a scientist and mentor, Cathy and Terry Olkin '88 have made a generous gift to launch fundraising for a new James L. Elliot (1965) Graduate Student Support Fund to benefit future generations of planetary scientists. (If you'd like to help, please see page 19!)

Earth. Planets. Climate. Life. EAPS research and educational programs are motivated by the quest to understand these overlapping and interconnected systems, the need to train the next generation of earth and planetary scientists, and the obligation to provide the data and scientific knowledge that leaders in government and industry need to better prepare for what is to come. With climate change now on MIT's radar and regular newsflashes about its impacts clamoring for our attention, this issue of EAPS Scope highlights our climate research, from the fundamental to the more applied. From paleoclimate and causes of mass extinctions, to present day atmospheric trends, carbon sequestration, the waxing and waning of polar icecaps, the influence of local climates on landslides, and research into the origins of greenhouse gases, here you can read about how EAPS scientists are unraveling the mysteries of the planet's complex climate systems.

As 35 new graduate students from eight countries settle into EAPS and the MIT-WHOI Joint Program for Oceanography this year, please remember it is your financial support that provides the fuel to keep the Department of Earth, Atmospheric and Planetary Sciences vibrant and strong. We offered 16 student fellowships this year thanks to the generosity of alumni and friends! Our long-term vision is to be able to provide fellowship support to all EAPS graduate students in the two years leading up to their general exam. Towards this goal, we aim to expand our cadre of 'climate fellows' (adding to the Norman C. Rasmussen Fellowships generously endowed last year by Neil Rasmussen '76, SM '80* and Anna Winter Rasmussen) by adding at least five new endowed fellowships over the next five years—ensuring we continue to attract the brightest and best climate scientists to MIT. We owe it to our future.

I invite you to learn more about our scientists and students by viewing our short video which reveals the core of our research and our mission: *http://bit.ly/eaps-mission*

With gratitude,

Rob van der Hilst
EAPS Department Head and Schlumberger Professor of Earth Sciences

GRADUATE STUDENT RESEARCH PROFILES

MARY KNAPP

In our own solar system, the Earth, Jupiter, Saturn, Uranus, and Neptune produce eerie-sounding radio choruses due to the interaction between the solar wind and the planets' magnetic fields. It has long been suspected that exoplanets produce similar radio emissions, but no detections have been made to date. My work is focused on observing large 'super-Jupiter' exoplanets in very eccentric orbits around their host stars. HD 80606b is a prime example of this class of exoplanets—it is 4 times the mass of Jupiter and has a comet-like eccentricity of 0.93 which brings it within 7 stellar radii of its parent star at closest approach. We use the LOFAR ('Low Frequency Array') telescope in the Netherlands to 'listen' to HD 80606b and similar planets in the 30-75 MHz range in the hope of detecting their radio songs. If we can detect radio emission from an exoplanet, we can determine how strong the planet's magnetic field is, how fast it rotates, and perhaps how its interior is structured. Radio observations will complement other methods used to study exoplanets to provide a fuller picture of exoplanetary structure, composition, and evolution. Based on our current understanding of solar system planets, particularly Earth and Mars, we believe that magnetic fields critically affect atmospheric evolution on rocky planets. Taking the first step in this field by detecting radio emission from a Jovian mass planet will pave the way for studies of small, rocky planet magnetic fields and hopefully improve our understanding of exoplanet habitability.

MINGWEI LI

Having personally experienced the periodic haze events in Beijing for several years, I became passionate about helping people to breathe clean air. This is why I was delighted to begin research at EAPS two years ago with the goal of answering an even bigger question: could China address climate change and air pollution at the same time? The context of this question is that greenhouse gases and conventional air pollutants share many common sources, and in the case of China, the dominant source is coal combustion. Therefore efforts to limit coal use in China could be expected to not only help tackle climate change, but also to have air quality co-benefits locally in China and even across the Pacific Ocean in the U.S.

In collaboration with the Tsinghua-MIT China Energy and Climate Project, we coupled two state-of-the-art models—an energy-economic model with sub-national detail for China (C-REM) and a global atmospheric chemistry model (GEOS-Chem) to investigate the effects of climate policies in China on air quality. In a carbon intensity scenario which achieves China's newest commitment to have its CO2 emissions peak in 2030, the annual PM2.5 concentrations are reduced on average by 19 μg/m3 in Eastern China and 0.1 μg/m3 in the U.S. compared to the business-as-usual scenario. We found that although end-of-pipe solutions are still needed to address the near-term air pollution problem in China, a gradual shift away from coal should ensure China will be able to meet both air quality and climate goals in the long term.

LEFT
Mary Knapp stands beside one of 256 low frequency antennas composing the Long Wavelength Array in New Mexico

RIGHT
Mingwei Li collaborates with the Tsinghua-MIT China Energy and Climate Project

Photo credits: Mary Knapp; Xiaoming Sun

LEFT
Laura Stevens retrieves GPS equipment on the Greenland Ice Sheet.

RIGHT
David Wang collects a fluid sample from a seep at The Cedars in northern California.

Photo credits: Joe Raedle; Penny Morrill

LAURA STEVENS

For two summers I've been busy traveling to the Greenland Ice Sheet. My fieldwork involves maintaining an array of GPS stations that continuously track the surface position of the ice sheet surrounding a couple of supraglacial lakes—lakes which form on the surface in summer when temperatures rise above freezing. In 2008, my advisors published the first GPS observations of the dramatic exit these lakes make; kilometer-long hydro-fractures rapidly grow and split through the lake bed, draining the entire lake through a kilometer of glacial ice to the bedrock below in a matter of hours [1]. The water from the drainage lubricates the interface between the ice sheet and bedrock, causing the ice sheet to speed up and advect ice faster to the coast. Their exciting finding received significant attention due to the potential implications for Greenland's future contributions to sea level rise.

The next questions to ask were "What is the mechanism that triggers hydro-fractures?" and "Will future warming lead to inland lake drainages causing enhanced ice flow in current slow velocity areas?" We deployed 20 GPS stations near a supraglacial lake and recorded the response to three drainages in 2011–13. We combined our GPS observations with methods from the geophysics/tectonics community to invert the data during the events, allowing us to see the distribution of meltwater at the ice sheet bed before, during and after the drainages. We discovered hydro-fractures were triggered by meltwater that reaches the ice sheet bed in the 6–12 hours before the lake drains [2]. This precursory meltwater caused basal slip and surface uplift in the lake basin, inducing local stress perturbations favoring crack initiation. Our findings allow us to hypothesize that as there are fewer pathways for meltwater to reach the bed in inland regions of the ice sheet, these lakes are less likely to drain in situ via hydro-fractures.

[1] Das et al., Science, 2008.; [2] Stevens et al., Nature, 2015.

DAVID T. WANG

Last summer, I traveled to the wine country of California to collect fluid samples. Specifically, my fieldwork involved a site called The Cedars in the northern Coast Ranges of California, at which groundwaters seep from exposed units of serpentinite, a rock type formed by weathering of ultramafic mantle rocks. These waters carry copious quantities of hydrogen and methane, and are highly-alkaline (pH values up to 12). Because of the hostile conditions for microbial life, methane from serpentinizing fluids is commonly assumed to be of non-biological origin.

I tested this assumption by quantifying 13CH3D, a low-abundance "clumped" form of methane containing two heavy isotopes, in these samples using a prototype high-precision laser spectroscopy instrument [1] similar to that on the Curiosity rover. Working with my advisor Shuhei Ono, fellow graduate student Danielle Gruen, and two dozen colleagues from academia, industry, and government, we have measured 13CH3D in methane samples from major natural reservoirs (gas hydrates, coalbeds, shales) and sources of atmospheric emissions (cattle, wetlands, lakes), as well as methane produced by microbes grown in the lab [2]. We determined that measurement of 13CH3D can be used to distinguish between biological and non-biological methane-generation pathways.

Surprisingly, I found that the methane from The Cedars carried an "anticlumped" signal characteristic of biological methane, suggesting that, despite the inhospitable conditions, life survives in this environment. If so, clumped isotope measurements of methane could be a valuable addition to the arsenal of biosignature detection tools, particularly on planets such as Mars where ultramafic rock is abundant.

[1] Ono et al. (2014) Anal. Chem.; [2] Wang et al. (2015) Science.

SUPPORT THE DEPARTMENT

Earth. Planets. Climate. Life.

The Department of Earth, Atmospheric and Planetary Sciences (EAPS) is the place at MIT where the inaccessible depths of inner Earth, alien landscapes of distant planets, turbulent oceans and atmospheres, and the origins of life all come together under one intellectual roof.

EAPS is all about hard, quantitative science, academic rigor, hands-on training, big data, collaboration, and the cross-fertilization of ideas—encompassing atmospheric science, climate, geobiology, geology, geochemistry, geophysics, oceans and planetary sciences. This fusion of disciplines creates a vibrant learning community that prepares EAPS undergraduate and graduate students for out-of-the-box thinking and future leadership.

Why support EAPS? Because our fundamental research leads us to important new discoveries and a better understanding of earth, planets, climate, and life. We are training tomorrow's scientific leaders and innovators whose research will help us understand today's unprecedented global changes: accelerating warming of our planet, pollution of our atmosphere and oceans, depletion of Earth's resources, and escalating risks from natural hazards such as hurricanes, storm surges, earthquakes, landslides, and rising seas. More than ever before, your support ensures that we will be armed with the people and scientific resources required to analyze and confront these challenges, and to help guide policy-makers, and government and industry partners, towards a more sustainable future.

Giving Opportunities

Gifts from alumni and friends provide the vital fuel for EAPS education and research—and it is our graduate students who power our pioneering work. Please make an annual gift to ensure that EAPS can attract top students and retain the best faculty. Every single gift makes a difference! Our funding priorities include:

• The EAPS Discretionary Fund (2734903) provides the most flexible support for students and faculty (e.g. to seed new research, purchase equipment, and cover student travel to conferences).

• The EAPS Graduate Student Support Fund (3857220) provides expendable funding for EAPS graduate students of any discipline.

Or support EAPS graduate students in specific areas of study via a named fund:

• James L. Elliot Graduate Student Support Fund (3297565) NEW!

• M. Nafi Toksöz Fellowship Fund (3311750)

• Theodore Richard Madden '49 Fellowship Fund (3305800)

• Sven Treitel '53 Graduate Student Support Fund (3312160)

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To make a gift of appreciated securities, or for more information about giving to EAPS via your estate plan, please contact Angela Ellis, EAPS Senior Development Officer:

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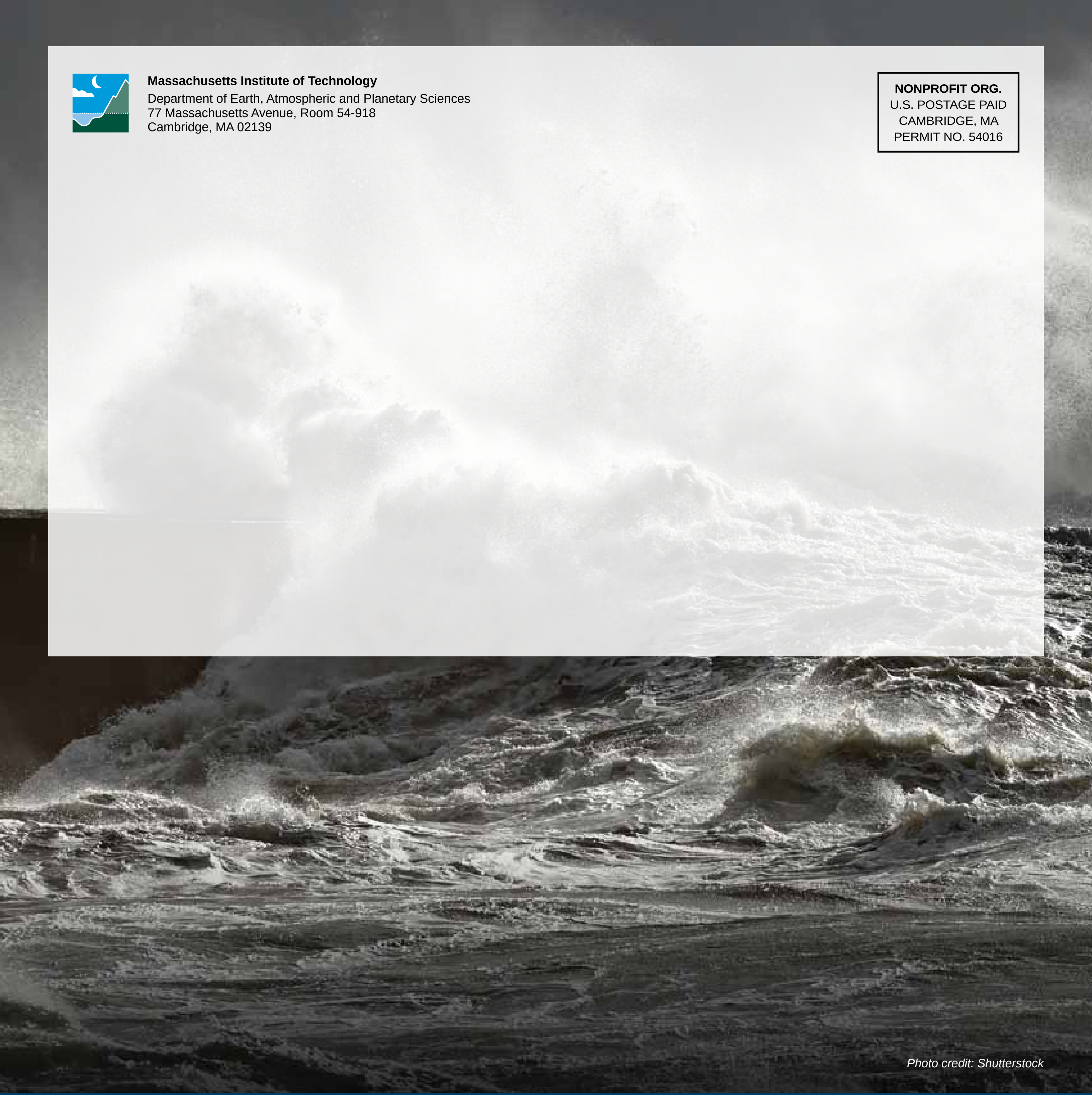

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