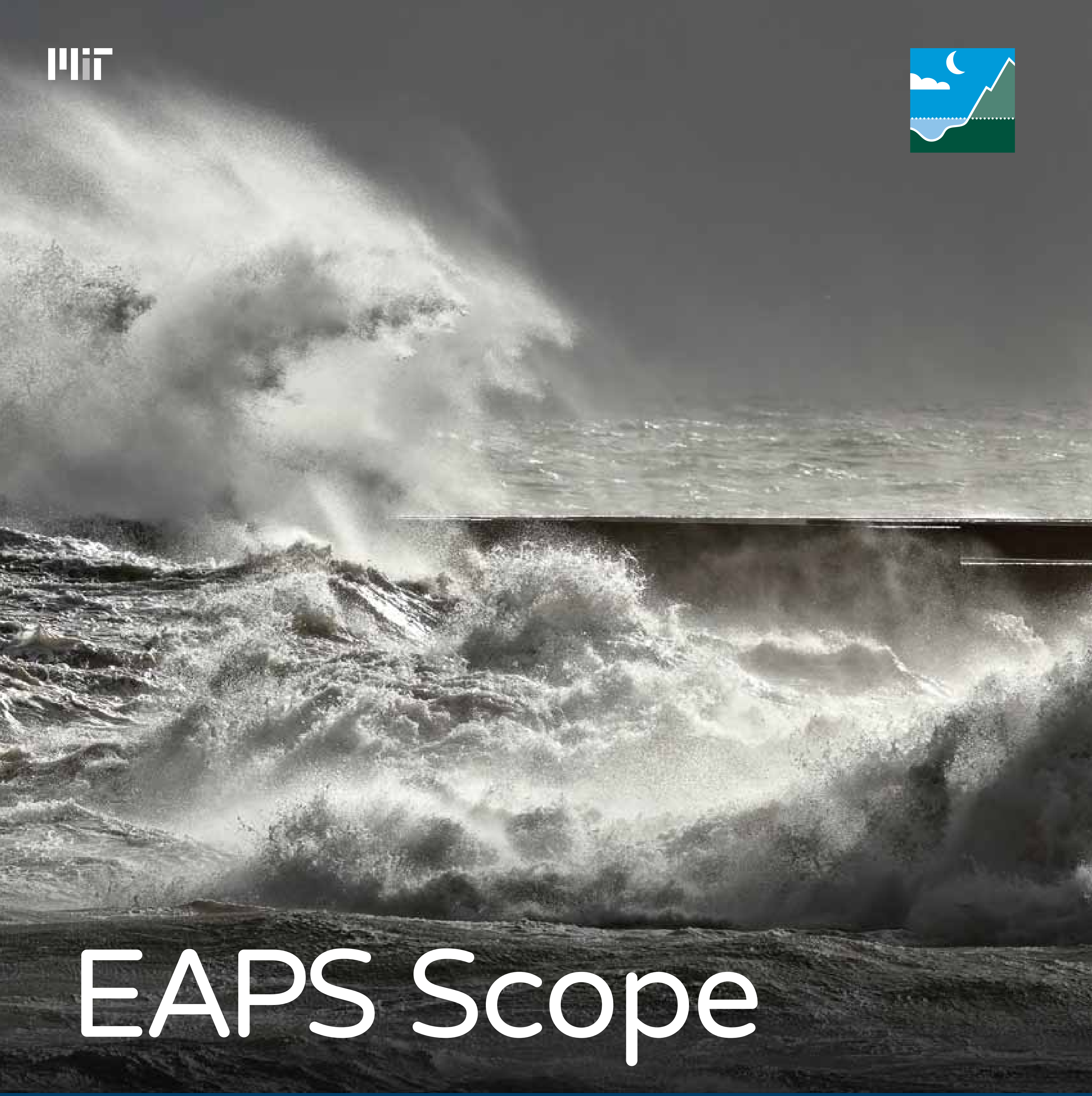

EAPS Scope

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

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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

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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

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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 news-flashes 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

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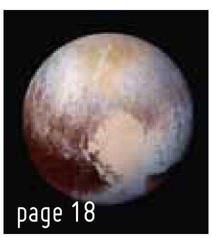

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by Cassie Martin

ANTARCTIC SEA ICE AND THE OZONE HOLE: A MATTER OF TIME

A recent multi-institution study, co-authored by John Marshall, Alan Plumb, and Susan Solomon, reveals complicated connections between ozone, oceans, and warming polar regions.

ANTARCTICA AND ITS SURROUNDING OCEAN present a fascinating mystery which could hold answers to some of today's most pressing climate change questions. MIT researchers have spent decades studying this complex environment—from the physical dynamics of the Southern Ocean below to ozone depletion in the atmosphere above. Now they are combining their expertise to understand how the atmosphere and ocean work together in the climate system.

MIT faculty John Marshall, Alan Plumb, and Susan Solomon, world authorities on the Southern Ocean and Antarctic ozone hole, formed the Ozone and Climate Project, which is part of the NSF Frontiers in Earth System Dynamics project. The ambitious five-year study, in collaboration with colleagues from Columbia University, Johns Hopkins University, and the National Center for Atmospheric Research, aims to understand how the Antarctic ozone hole affects climate by watching what happens as it heals.

"We have a unique opportunity to examine the basic robustness of the climate system as it reacts to and recovers from the ozone hole, while also responding to ever increasing greenhouse gas concentrations," said Marshall, lead investigator and the Cecil and Ida Green Professor of Oceanography. "And so we've assembled a uniquely cross-disciplinary, multi-institutional project team to match."

As Arctic sea ice melts at an alarming pace, Antarctic sea ice continues to expand, perplexing scientists. Some climate models of the region indicate sea ice should be melting. Ideas as to why sea ice is shrinking in the northern hemisphere and growing in the southern hemisphere abound, but a prominent theory points to the influence of ozone—or lack thereof. In results from the study published earlier this year in the Journal of Climate, the researchers provide a better understanding of ozone's role and why sea ice continues growing in a rapidly warming world.

"[This research] highlights the strong interaction between the ocean and the atmosphere in the climate system," said Solomon, the Ellen Swallow Richards Professor of Atmospheric Chemistry and Climate Science. "It shows how important the ocean actually is and it's helping to define what questions we should be asking of our models for climate change and the Antarctic in particular."

Ozone depletion peaked at the turn of the milennium and is slowly stabilizing thanks to policy changes which were spurred by Solomon's research. But the hole, still hovering over Antarctica, has combined with increasing greenhouse gas concentrations to cause strong westerly winds that cool the Southern Ocean's surface, enhancing sea ice growth.

Although observational data support this interpretation, some model simulations beg to differ. Various studies investigating the impact of ozone depletion on Earth's oceans found that when ozone is reduced or removed, wind strength increases as expected. However, instead of cooling sea surface temperatures (SSTs), the increased winds induce upwelling of warm water to drive a warming trend.

"That's where ideas clash," said study lead author David Ferreira, a lecturer at the University of Reading and former MIT researcher. "There was a lot of confusion because models of ozone depletion were not explaining sea ice expansion." University of Washington Atmospheric Chemist Cecilia Bitz also contributed and co-authored the study.

Using MIT's Global Circulation Model (MITgcm), the researchers looked at ocean-atmosphere-sea ice simulations over various time periods ranging from years to decades. They found that while SSTs cool and sea ice expands under ozone forcing in the short-term, ultimately the oceans warm and sea ice declines. In other words, both real-world observations and model simulations are correct, they just happen on different timescales. Eventually, we may start to see model outcomes—ocean warming and Antarctic sea ice decline—become reality.

The study may have resolved a key discrepancy between models and observations, but there are still questions left unanswered, such as when Antarctica's sea ice decline will begin, if at all. The models agree that the ocean's response to ozone depletion is a complex process of cooling then warming, but they don't agree on when the temperature transition will happen.

"Ocean temperature transitions typically take anywhere from 5 to 20 years," said Ferreira. "We can't predict exactly when Antarctic SSTs will begin warming, because we don't yet fully understand all the processes that will conspire to control the timing."

The researchers are currently working on constraining their models with more real-world data to better understand the mechanism of this two-timescale process and make predictions of when we can expect Antarctica to begin warming.

"As time passes, it is going to be a race to see whether the ozone hole will heal before the deep ocean has a chance to reassert itself," Solomon said. "I'm interested to see what happens in the next decade. It's going to be about time to see the other timescale pretty soon; it could be any year now."

Read more about the research: http://bit.ly/ozone-ice

SHIFTING CLIMATES. SHIFTING LANDSCAPES.

A new landslide prediction model from Dino Bellugi, Taylor Perron, and Paul O'Gorman could help communities prepare for disaster in the face of changing climate.

by Cassie Martin

LEFT
Landslides from recently logged slopes dumped millions of tons of mud and debris into Stillman Creek, near Curtis, WA, in December 2007

Photo credit: David E. Perry

TAYLOR PERRON HAS SEEN the aftermath of landslides firsthand. As a graduate student at the University of California at Berkeley, the MIT professor surveyed resulting debris flows and damaged infrastructure in California. "It really made me sit up and take notice," he said. "We're used to thinking about many geological processes as being gradual, but to be able to understand something that happens that quickly and has such destructive power was something I knew I needed to do."

Many landslides are triggered by extreme precipitation events—large amounts of rain falling over short periods of time—which are increasing in both intensity and frequency. Predicting where landslides are more likely to happen is paramount for vulnerable communities adjusting to a changing climate, but the task isn't easy.

"The challenge of predicting landslides is somewhat like the challenge of predicting earthquakes," said Perron, now Associate Professor of Geology in MIT's Department of Earth, Atmospheric and Planetary Sciences. "We know enough to be able to map out the susceptibility of different areas, but knowing where and when an individual event will strike is a different matter." Thanks to a new model developed by MIT researcher Dino Bellugi, landslide prediction may no longer be a far-off goal.

The model predicts individual landslide locations and sizes, and the researchers are taking the innovation a step further. Perron and Bellugi have teamed up with EAPS Associate Professor of Atmospheric Science Paul O'Gorman to integrate this model with models of extreme rainfall to see how landslides might shift under different climate scenarios.

"This is a real challenge to construct and use this kind of landslide model and figure out how to integrate that with climate science," Perron said. "If we succeed, the output is going to be something that really matters on a timescale of years to decades."

First, the researchers coupled a landslide search algorithm with a model that uses soil depth, root strength, and pore water pressure to assess the ground stability of a defined region—in this case, a research site in the Pacific Northwest prone to landslides. "The research at this site gave us a natural experiment where we know the landslide pattern in recent history and have several important parameters constrained by the field research there," said Bellugi. "It was a natural site to test our model."

Bellugi and Perron mapped the resulting output and compared it to known landslides. They found that the predictions overlapped well with mapped observed landslides—not just in location, but in size as well. In the future, the model could be used to predict locations where landslides have yet to occur.

Next, O'Gorman and Bellugi combined the landslide model with a spatially resolved climate model that provided an estimate of regional precipitation changes near the end of this century. A statistical analysis of the resulting output revealed that a 10 to 20 percent increase in the intensity of extreme rainfall, and even larger increases in previously drier areas, was likely.

"A 20 percent increase in precipitation intensity, which is what we expect and models predict, may be enough to open up windows of opportunity for landslides to occur in places that aren't currently considered hazardous," said Bellugi. These areas won't necessarily see an increase in average rainfall, but they will see more extreme precipitation events, which puts them at greater risk for landslides. "Risk is not just about hazard, it's also about people's exposure to that hazard," Perron added. "If people are not used to being exposed to a hazard and then become exposed, the risk can increase dramatically."

The next goal on the trio's agenda is connecting their model to one that predicts how far debris flows—by far the most dangerous part of landslides—will go, and how close they will come to communities and infrastructure. "If you can tell people something more concrete—'here you'll have an increased risk, get prepared'—that may be something that can be easily translated to policy," Bellugi said.

Read about the research:
http://bit.ly/tperron
http://bit.ly/ogorman
http://bit.ly/bellugi

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:

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