

A group of approximately 15 people, including students and staff, are walking across a suspension bridge in a dense forest. The bridge is made of metal and has a chain-link fence railing. The forest is lush with green trees and foliage. The scene is captured from a low angle, looking up at the bridge and the people walking on it.

College of Earth, Ocean, and Atmospheric Sciences

Research Highlights 2015–16

Oregon State
UNIVERSITY

About the College

Oregon State University's College of Earth, Ocean, and Atmospheric Sciences is an internationally recognized leader in the study of the Earth as an integrated system. The college operates numerous state-of-the-art analytical laboratories, core repositories and three oceanographic research vessels, the 177-foot ocean-going *Oceanus*, the 84-foot coastal research vessel *Pacific Storm* and the 54-foot coastal research vessel *Elakha*. The college's annual budget of more than \$50 million includes numerous research grants from the National Science Foundation, National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration, and other federal agencies and philanthropic organizations. With over 100 faculty, 200 graduate students and 600 undergraduate students, the college has vibrant educational programs that span Earth system science. Graduate programs include master's and Ph.D. degrees in Ocean, Earth and Atmospheric Sciences; Geology; and Geography and a master's degree in Marine Resource Management. The college has undergraduate programs in Earth Sciences and Environmental Sciences, with several minors and certificate programs that provide students with the tools to pursue graduate study and find rewarding careers in management, planning and government.

Contacts

College of Earth, Ocean, and Atmospheric Sciences
Oregon State University
104 CEOAS Admin Building
Corvallis, OR 97331-5503
541-737-3504
ceoas.oregonstate.edu

Roberta Marinelli, Dean,
541-737-5195
Anita Grunder, Associate Dean for Academic Programs,
541-737-5189
Student Services,
541-737-1201
Doug Brusa, Director of Development,
541-207-8686



Oregon State University's College of Earth, Ocean, and Atmospheric Sciences is at the forefront of observing and understanding our ever-changing planet. As the new dean, I am inspired by the college's scientists and problem-solvers, people who are dedicated to foundational research that is truly changing the world.

Faculty and student researchers in the college are helping to understand marine dead zones, climate change, hazards, harmful algal blooms, changing landscapes and the impact to society, wave energy potential and interactions between ocean conditions and commercial fishing stocks. Foundational and use-inspired research allows stakeholders to make informed choices about natural resources and benefits the people who depend upon them.

This publication provides a snapshot of the college's outstanding people who are breaking boundaries and advancing our understanding of the Earth system. We hope you enjoy learning about what we've accomplished in the 2015-2016 academic year.

Roberta Marinelli, dean

Climate Change

Scientists recruit public to help study The Blob

A huge mass of unusually warm water that scientists have dubbed The Blob has lurked off the West Coast, and speculation is growing that it may be connected in some way with the 2015 drought that plagued West Coast states. An international research team that includes OSU scientists plans to run hundreds of variations of computer models aimed at calculating the influence of The Blob on West Coast climate.

The amount of data that such a project creates is staggering and could require as many as three supercomputers to generate. Rather than go it alone, the team will rely on thousands of citizen science volunteers to run simulations during idle times on their personal computers.

It is part of an umbrella project originally launched by Oxford University in 2003, and joined by researchers at Oregon State University in 2010, to use the combined power of thousands of individual computers to run climate modeling simulations. This latest project is supported by Climate Central, an independent organization of leading scientists and journalists researching and reporting on changing climate.

"It takes about a week to run a year-long unit of climate data, and the program is set up to automatically feed the results back to the scientists," said **Phil Mote**, director of the Oregon Climate Change Research Institute at Oregon State University and a principal investigator on the project. "It's a great way for the general public to help the scientific community investigate some of the climate variations we're seeing."

To test the connection between The Blob and the drought, the research team will compare oceanographic and climate data from an 18-month stretch (Dec. 1, 2013 to May 31, 2015) – including observed sea surface temperatures – with other 18-month stretches from 1981 to 2010. By running hundreds of computer models with slight variations, they hope to be able to determine what impacts The Blob and its swath of warm water have had on West Coast climate.



Peter Clark

Distinguished Professor

Oregon State University has named Peter Clark as a 2016 Distinguished Professor recipient, the highest academic honor the university can bestow on a faculty member. Professor Clark uses climate change in the geologic past to highlight processes relevant to the future climate. His research emphasizes the role of glaciers and ice sheets in the global climate system. This work is central to the debate about future sea-level changes related to melting of land-based ice, which will likely be one of the major long-term outcomes of anthropogenic warming driven by rising greenhouse gases.

The long view on climate change

At the rate humans are emitting carbon into the atmosphere, the Earth may suffer irreparable damage that could last tens of thousands of years, according to a new analysis published in *Nature Climate Change*.

Too much of the climate change policy debate has focused on observations of the past 150 years and their impact on global warming and sea level rise by the end of this century, the authors say. Instead, policy-makers and the public should also consider the longer-term impacts of climate change.

"Much of the carbon we are putting in the air from burning fossil fuels will stay there for thousands of years – and some of it will be there for more than 100,000 years," said **Peter Clark**, an Oregon State University paleoclimatologist and lead author on the article. "People need to understand that the effects of climate change on the planet won't go away, at least not for thousands of generations."

Sea level rise is one of the most compelling impacts of global warming, yet its effects are just starting to be seen. The latest IPCC report, for example, calls for sea level rise of just one meter by the year 2100. In their analysis, however, the authors look at four different sea level-rise scenarios based on different rates of warming, from a low end that could only be reached with massive efforts to eliminate fossil fuel use over the next few decades, to a higher rate based on the consumption of half the remaining fossil fuels over the next few centuries.

With just two degrees (Celsius) warming in the low-end scenario, sea levels are predicted to eventually rise by about 25 meters. With seven degrees warming at the high-end scenario, the rise is estimated at 50 meters, although over a period of several centuries to millennia.

Clark said for the low-end scenario, an estimated 122 countries have at least 10 percent of their population in areas that will be directly affected by rising sea levels, and that some 1.3 billion – or 20 percent of the global population – live on lands that may be directly affected. The impacts become greater as the warming and sea level rise increase.

Daniel Schrag, the Sturgis Hooper Professor of Geology at Harvard University, said there are moral questions about "what kind of environment we are passing along to future generations."

"Sea level rise may not seem like such a big deal today, but we are making choices that will affect our grandchildren's grandchildren – and beyond," said Schrag, a co-author on the analysis and director of Harvard's Center for the Environment. "We need to think carefully about the long time-scales of what we are unleashing."



Coastal and Near-Shore Oceanography

Impacts of El Niño, La Niña on coastal communities could expand in 21st century

A coastal hazards analysis of 48 Pacific Ocean beaches in three continents (North America, Asia and Australia), using data from 1979 to 2012, found the biggest factor influencing communities and beaches in all regions was the impact of El Niño and La Niña events.

The study also found their influence had alternate impacts in different parts of the Pacific basin. When one side of the Pacific experienced extreme coastal erosion and flooding because of El Niño, the other side often experienced these hazards during La Niña. Some climate projections suggest that these events may occur more frequently in the 21st century, meaning that populated regions could experience more severe flooding or erosion.

"There are many factors that can influence coastal vulnerability yet many future projections of coastal hazards focus only on sea level rise and neglect the influence of seasonal water level anomalies, storm surges, wave-driven processes and other factors," said **Peter Ruggiero**, an Oregon State University coastal hazards expert and co-author on the study.

"We knew that climate cycles play a major role in what happens to our coastlines, but the fact that El Niño and La Niña significantly affect coastal hazards throughout the Pacific in a fairly coherent manner was a bit of a surprise," added Ruggiero.

The analysis also confirmed what scientists had suspected – the most dominant impacts on beaches and communities through climate cycles takes place in the boreal (northern) winter. Some projections suggest that the worst-case scenarios for sea level rise could displace up to 187 million people by the end of the 21st century, with flood losses exceeding \$1 trillion (in U.S. dollars) for the world's major coastal cities.

Since the study's release, Ruggiero noted that the El Niño winter of 2015-2016 was one of the strongest on record.

"Observed winter wave energy equaled historical maxima across much of the U.S. West Coast, and water level anomalies were high, corresponding to anomalously large beach erosion across the region," he said. "Shorelines in many areas retreated beyond landward historical extremes, particularly portions of the California coast that are sediment starved."



Melissa Errend

Putting the sea in D.C.

Melissa Errend is a catalyst in the ongoing reaction between science and policy. The CEOAS graduate was recently recognized for her accomplishments by her selection as a 2016 Knauss Fellow by Oregon Sea Grant. With oversight by the National Sea Grant office, the prestigious John A. Knauss Marine Policy Fellowship places graduate students focused on ocean and Great Lakes studies in legislative or executive offices in Washington, D.C., for a year, where they learn how government functions and contribute their expertise to science policy.



Solid Earth

When the poles shift: Dating ancient magnetic excursions

Magnetic pole shifts might be the stuff of Hollywood blockbusters, but they are important for understanding the stability of the Earth's magnetic field, which shields us from pummeling radiation. Geomagnetic excursions are less dramatic than reversals, causing short-lived reductions in field intensity with a major change (but no reversal) in the location of the magnetic pole. Still not fully understood is how the magnetic field changes and why it behaves so differently during excursions or reversals. Documenting the timing, duration and frequency of these magnetic anomalies is the first order of business to help characterize the behavior of the Earth's magnetic field over geological time.

Scientists from the College of Earth, Ocean, and Atmospheric Sciences who are studying this important phenomenon have published a new paper that reveals a dramatic reduction in field strength and a shifting of the geomagnetic poles that took place roughly 930,000 years ago.

The research team, including recent Oregon State University Ph.D. graduate **Andrea Balbas** and co-author **Anthony Koppers**, sampled basaltic lava flows on Floreana Island in the Galapagos Archipelago. Certain rocks and other materials preserve a record of the direction and intensity of the Earth's magnetic field when they form, allowing scientists to essentially go back in time and view past conditions. Using argon isotopes ($^{40}\text{Ar}/^{39}\text{Ar}$), the research team was able to precisely date the so-called Santa Rosa excursion, which featured a record-breaking 86 percent reduction in the Earth's magnetic field strength. The results are especially encouraging because they uphold findings from two volcanic and three sedimentary archives, providing evidence for a short-lived geomagnetic anomaly of global significance that scientists can now place in the geomagnetic polarity time scale.

"The Santa Rosa is a significant and short-lived geomagnetic excursion, and our new $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology dates show that the Earth's geodynamo can dramatically alter the geomagnetic field in just a few millennia," said Koppers, a marine geologist.

Scientists say the results provide a critical contribution to understanding the global geomagnetic field and excursions. "Our results provide strong limits on geodynamic models that allow us to simulate how changes in the Earth's inner core can trigger a dramatic and quick geomagnetic excursion," Koppers said. "More broadly, dating this spectacular lowering of the geomagnetic field strength is important for understanding the long-term behavior of the Earth's magnetic field and its role in protecting our planet from the deadly solar and galactic radiation."



Christopher (Gabe) Creason

NSF East Asia and Pacific Summer Institute (EAPSI) Award

Ph.D. student Christopher (Gabe) Creason received a prestigious East Asia and Pacific Summer Institute (EAPSI) Award from the National Science Foundation for his research in China. Creason will conduct research into the growth and evolution of high topography along the eastern margin of the Tibetan Plateau. His visit includes collaborations with Chinese scientists at the Chinese Academy of Sciences (Beijing) and the Chengdu University of Technology (Sichuan).

Ocean/Air Fluxes, Flows

Study finds limit on evaporation to ice sheets, but that may change

The vast interior of the Greenland Ice Sheet has remained relatively stable, thanks to a strong thermal “lid” that essentially traps the moisture and returns it to the surface where it refreezes. But new evidence suggests this lid is becoming leaky as global temperatures increase. The researchers say there may be a threshold at which warming becomes sufficient to turn on a switch that will destabilize the snow surface.

New measurements from a research tower atop the Greenland Ice Sheet helped uncover the mystery of how much snow piles up on this ice sheet.

“Normally, the air temperature goes down as you climb, but near the surface in Greenland, it gets warmer,” said **David Noone**, an Oregon State University professor who is an atmospheric scientist and principal investigator on the study. “The surface is very cold, but it can be as much as 20 degrees warmer just 30 to 40 feet up in the air. It’s enough that you can feel the difference between your nose and your toes.”

“The temperature difference effectively forms a lid so that there is hardly any evaporation. Warm air likes to rise, but if it is already warmer up above, the air is trapped nearer to the ground. One consequence is that layers of fog form from water that had recently evaporated. Eventually the small fog water-drops drift back down to the very cold surface where it refreezes onto the ice sheet.”

To understand past climate, scientists must know how much precipitation fell and how much evaporated. Without the team’s analysis, what fraction of falling snow accumulates and what fraction evaporates was difficult to determine. When they began to explore evaporation rates, they discovered this unique thermal lid, which effectively “recycles” water back onto the Greenland Ice Sheet. This finding will allow previous estimates of Greenland’s past water balance to be re-evaluated.

“Climate models suggest that as temperatures increase, more precipitation may actually fall in Greenland because warmer air can hold more water. Taken by itself, that could indicate that parts of the ice sheet may grow. However, if the lid becomes increasingly leaky, the evaporation process has become more effective, and moisture will escape to the atmosphere.

“The fate of the ice sheet is in the balance,” Noone said. “It becomes a question of which influence is stronger.”



Roger Samelson

AGU and AMS Fellow

Physical oceanographer and atmospheric scientist Roger Samelson was named a 2015 Fellow of the American Geophysical Union and a 2016 Fellow of the American Meteorological Society. As

the author or co-author of over 90 peer-reviewed research publications, he has made several noteworthy contributions to his field, including developing a new description of the fluctuating currents that are found throughout the World Ocean. These features can be thought of as the ocean’s internal weather systems, and their cumulative effect is believed to have an important influence on the Earth’s climate.



Briana Phillips

Keeping an eye on The Blob

Briana Phillips is a master’s student at Oregon State University and recipient of a NASA Earth and Space Science fellowship. Working with atmospheric scientist Larry

O’Neill, she is researching the huge mass of unusually warm water called The Blob in the North Pacific gyre. Her research will help shed light on The Blob’s far-reaching implications, from disruptions in the food web to drought in the U.S. West.

Geospatial Sciences

Mapping the war in Syria

Since the first shot was fired by the Syrian army in March 2011, millions of pounds of ammunitions have landed in and around Aleppo, a city that was home to 2.3 million people as of 2005. As the hotspot of the Syrian Civil War, Aleppo is often shown as a shell of a city — destroyed by barrel bombs, explosions and small artillery fire. Yet the distribution of these damages has not been uniform across space and time. In addition, reports, photos and videos from journalists or civilians inadequately characterize the extent of the damage, leaving many unmapped spaces and undocumented changes over Aleppo.

To develop a new perspective on the effects of violence on Aleppo's population and infrastructure, Assistant Professor **Jamon Van Den Hoek** has turned to satellite-based remote sensing. He used nearly 200 open-access NASA/USGS Landsat satellite images to map the range of damage through time, offering a remotely collected record of significant damages over Aleppo measured twice a month for the last 64 months. The technique affords a more systematic perspective in its frequency of observation, point of observation and sensitivity to changes.

"Since I've used a series of satellite images collected only 16 days apart, I can identify discrete damages over the course of the war," said Van Den Hoek, a geographer in the College of Earth, Ocean, and Atmospheric Sciences. "For example, I can map damages near Aleppo's hospitals that have been repeatedly bombed, or track the war's impacts on the historic citadel. I can also visualize smaller-scale or relatively ephemeral changes that would go unnoticed in punctuated change assessments from monitoring groups such as the UN or Human Rights Watch."

Of special interest, Van Den Hoek's analysis has found extensive changes to the city's roadways and intersections that have been critical to transporting goods and aid; most of these changes have gone unmapped. Van Den Hoek has also created a composite map to visualize the total spatial distribution of damages over Aleppo since March 2011. The composite allows him to see features and regions that have been damaged the most frequently.

"By offering periodic as well as synoptic perspectives of the war, this approach offers inroads to better understanding the spatial distribution of damage across Aleppo," he said. "We can identify targeted communities and neighborhoods and better gauge the realities of a disastrous and ongoing war."



Ryan Crumley

Visualizing snow cover frequency

Ryan Crumley, a Ph.D. student in water resources science, is using Google Earth Engine to visualize snow cover frequency, a measure of how many times a place on Earth has snow within a certain date range. Because in-situ measurements of snow accumulation can be difficult—especially in remote locations—Crumley's work is providing insight into how warming temperatures may shift precipitation from snowfall to rainfall and impact future water management.

Elemental Cycles and Food Webs

Hydrothermal vents play enormous role in sustaining marine life and moderating climate

The hydrothermal vents and methane seeps on the ocean floor that were once thought to be geologic and biological oddities are now emerging as a major force that shapes ocean ecosystems, marine life and global climate.

However, as researchers learn more about their role in sustaining a healthy Earth, these unique habitats are threatened by a wide range of human activities, including deep-sea mining, bottom trawling and energy harvesting.

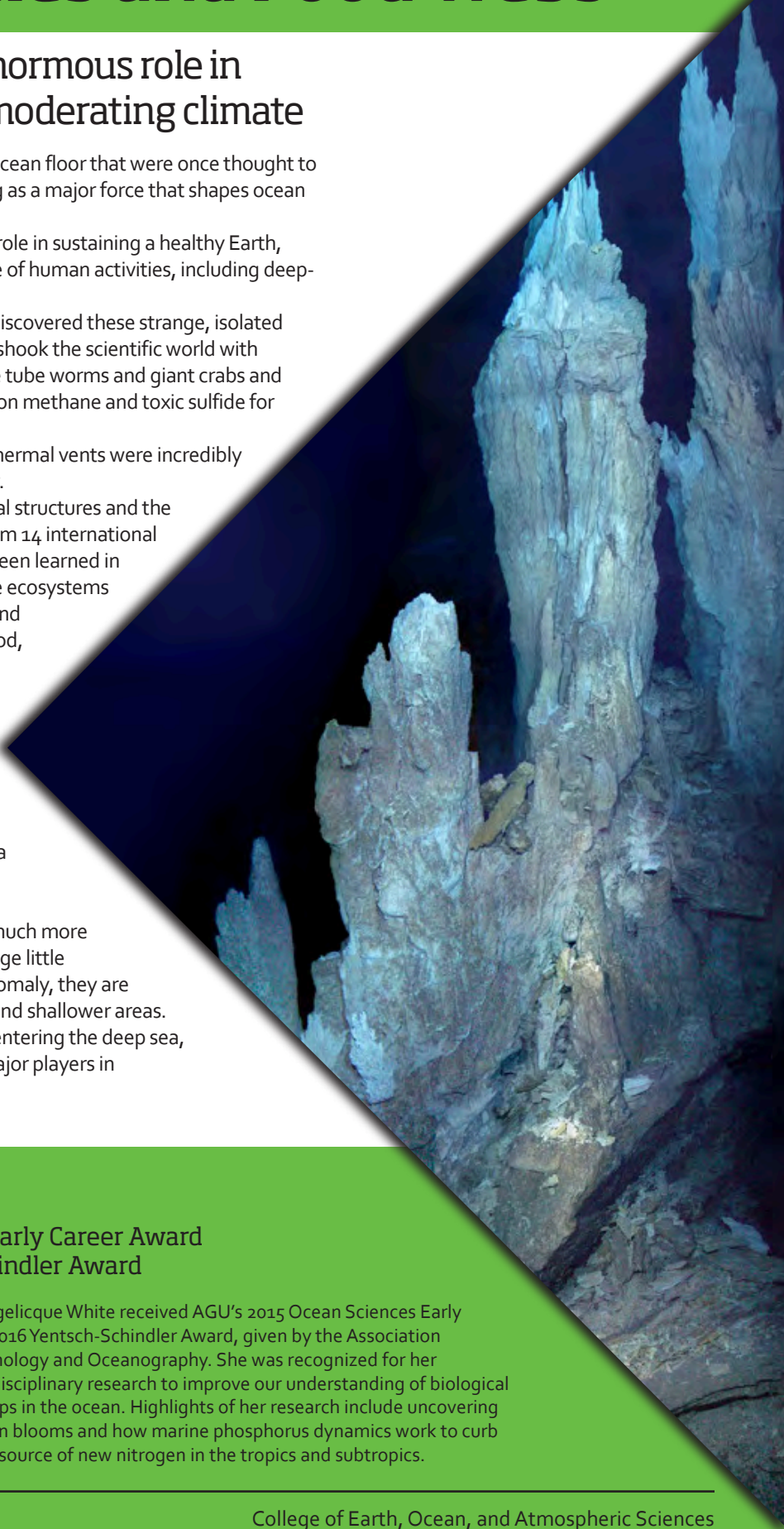
Researchers from Oregon State University first discovered these strange, isolated worlds on the ocean bottom 40 years ago. The news shook the scientific world with reports of hot oozing gases, sulfide chimneys, bizarre tube worms and giant crabs and mussels – life forms that were later found to depend on methane and toxic sulfide for their energy and metabolism.

"It was immediately apparent that these hydrothermal vents were incredibly cool," said **Andrew Thurber**, a co-author of the study.

In reviewing the status of these marine geological structures and the life that lives around them, a group of researchers from 14 international universities and organizations have outlined what's been learned in the past four decades and what forces threaten these ecosystems today. The range of ecosystem services these vents and seeps provide is just barely beginning to be understood, researchers said in their report.

As fountains of marine life, the vents pour out gases and minerals, including sulfide, methane, hydrogen and iron – one of the limiting nutrients in the growth of plankton in large areas of the ocean. Importantly, the life forms in these vents and seeps consume 90 percent of the released methane and keep it from entering the atmosphere, where as a greenhouse gas it is 25 times more potent than carbon dioxide.

"We've learned that these vents and seeps are much more than just some weird fauna, unique biology and strange little ecosystems," Thurber said. "Rather than being an anomaly, they are prevalent around the world, both in the deep ocean and shallower areas. They provide an estimated 13 percent of the energy entering the deep sea, make a wide range of marine life possible, and are major players in global climate."



Angel White

Ocean Sciences Early Career Award and Yentsch-Schindler Award

Associate Professor Angelique White received AGU's 2015 Ocean Sciences Early Career Award and the 2016 Yentsch-Schindler Award, given by the Association for the Sciences of Limnology and Oceanography. She was recognized for her groundbreaking, multidisciplinary research to improve our understanding of biological and physical relationships in the ocean. Highlights of her research include uncovering drivers of phytoplankton blooms and how marine phosphorus dynamics work to curb nitrogen fixation, a key source of new nitrogen in the tropics and subtropics.

Study finds native Olympia oysters more resilient to ocean acidification

Native Olympia oysters, which once thrived along the Pacific Northwest coast until over-harvesting and habitat loss nearly wiped them out, have a built-in resistance to ocean acidification during a key shell-building phase after spawning, according to a newly published study.

Unlike the commercially raised Pacific oysters, Olympia oysters don't begin making their shells until two to three days after fertilization and make them far more slowly. This helps protect them from corrosive water during this critical development phase, said Oregon State University's **George Waldbusser**, principal investigator on the National Science Foundation funded project.

In contrast, commercial Pacific oysters develop their calcium carbonate shell much faster — in about six hours. When exposed to acidified water, their energy stores become depleted because the cost to make the same amount of calcium carbonate increases. The rapidly developing Pacific larval oysters may get through the initial shell-building stage, Waldbusser said, but they often will not have enough energy to survive. This early exposure to elevated carbon dioxide among Pacific oysters is what triggered widespread hatchery failures.

While Olympia oysters are able to develop in surprisingly high levels of acidification, which is partially natural in Oregon's upwelled coastal waters, the trait is not because of changing ocean conditions. "They didn't develop that trait in response to rising acidification, or probably even in response to the naturally elevated carbon dioxide," said Waldbusser. "For the Olympia oysters, the slow-shell trait has most likely evolved for other reasons, and has been there for some time."

"Perhaps there are other traits in marine organisms that we're unaware of but may be beneficial in response to increasing acidification of our oceans and estuaries."

The research may have implications for the future of the commercial oyster industry, given that many of the problems associated with shell formation and development seem to originate at an early developmental stage. Cultivation of native oysters could help guard against catastrophic Pacific oyster losses due to acidification, the researchers say, but the economics and logistical hurdles currently limit these to niche markets. For now, they will not replace Pacific oyster cultivation. However, it may also be possible to breed some of the Olympia oysters' beneficial traits into Pacific oysters — either slowing the calcification rate of early larvae or producing fewer and bigger eggs.

Laurie Juranek

The dynamic Arctic and sea ice

Laurie Juranek and a team of 11 researchers from the College of Earth, Ocean, and Atmospheric Sciences embarked on the R/V Sikuliaq to investigate how Arctic sea ice change is affecting the region's chemistry and ecology, particularly primary productivity. Her research is important for understanding how climate change may disrupt the timing and availability of nutrients and food.



Water Resources

Comprehensive report of world's transboundary water basins finds hotspots of risk

The United Nations Environmental Group has just completed the most comprehensive assessment of the world's 286 transboundary river basins (rivers that cross at least one political border) yet attempted and identified hotspots where geopolitical risks are projected to increase in the next 15 to 30 years.

"The proliferation of dams and diversion of water from countries that are upstream from other nations that are dependent on that water is of growing concern," said **Aaron Wolf**, an internationally recognized water treaty expert from Oregon State University, who was involved in creating the report. "There simply isn't enough water to go around."

These transboundary river basins and other waterways span 151 countries

and include more than 40 percent of the world's population and land area. The analysis, "Transboundary Waters Assessment Programme," was a collaborative effort between eight international organizations and research institutes and Oregon State University.

Among the areas considered hotspots, the report concludes, are the Middle East, Central Asia, and the Ganges-Brahmaputra-Meghna basin.

Many of these hotspots have been known about for some time, but the baseline data in the assessment combined with the first comprehensive look at the impact of multiple stressors may allow policy-makers to get ahead of the curve before disaster strikes, Wolf said.

"From a geopolitical standpoint, if you can identify places where things have the potential to blow up before people realize it, you can jump-start the conversation and begin what we call 'preventive diplomacy,'" Wolf noted.

As an example, the Helmand and Harirud basins, shared by Afghanistan and Iran, have the potential for flare-up, Wolf said.

"The U.S. wants Afghanistan to develop its economy and become more independent, but Iran downstream also wants that water and has tenuous relations with us. We hope that the information in this report will provide early warning so appropriate actions can be taken to prevent escalating tensions."



Willamette Valley water future mostly bright

During the next 85 years, temperatures in Oregon's Willamette River basin are expected to rise significantly, mountain snowpack levels will shrink dramatically, and the population of the region and urban water use may double – but there should be enough water to meet human needs, a new report concludes.

Fish may not be so lucky. Although ample water may be available throughout most of the year, the Willamette Valley and its tributaries likely will become sufficiently warm as to threaten cold-water fish species, including salmon and steelhead, the scientists say.

These are among the key findings of the Willamette Water 2100 Project, a five-year, \$4.3 million study funded by the National Science Foundation and led by Oregon State University, in partnership with researchers from the University of Oregon, Portland State University and University of California at Santa Barbara.

"The Willamette River basin today is characterized by abundant annual water and sometime seasonal shortages," said **Anne Nolin**, an OSU professor and principal investigator on the study. "That should continue into 2100, despite much warmer temperatures, more people and a substantial loss of snowpack.

"The reason for optimism is the region's 11 storage reservoirs coordinated by the Army Corps of Engineers that act as a valve for seasonal differences and preserve water for times of need," Nolin added. "Without them, the picture would look quite a bit different."

Analysis of global circulation models suggest that the Willamette River basin will warm between two and 13 degrees (Fahrenheit) by the year 2100, thus scientists used three separate scenarios to look at potential impacts based on low, medium and high rates of temperature increase. These temperature increases will result in a dramatic decline in snowpack, changing seasonal water flow patterns.

"Unlike many parts of the country, those of us who live in the Willamette Valley are lucky because we have abundant water for human use, and we have institutional capacity to help mitigate water scarcity," she added. "However, the biggest negative impacts are likely to be for native cold-water fish, and we will likely be facing a significant challenge in managing stream temperature for fish."



Travis Roth

Satellite-based snow mapping

Travis Roth, a Ph.D. student in water resources science, has been selected to receive a NASA Earth and Space Science Fellowship. His project, "Understanding Forest Structure Effects on Snow Accumulation and Ablation for Improved Satellite-Based Snow Mapping and Model Characterization," was one of 73 selected out of 425 proposals to the Earth Science Division.



Shaded relief map of the Willamette River basin, looking to the west and the Pacific Ocean. Image credit: Charles Preppernau, OSU. Photo credits (top to bottom): USACE, OSU, OSU.

Natural Hazards

Study finds major earthquake threat from the Riasi fault in the Himalayas

New geologic mapping in the Himalayan mountains of Kashmir between Pakistan and India suggests that the region is ripe for a major earthquake that could endanger the lives of as many as a million people, according to a recently published article in Geological Society of America Bulletin.

Scientists have known about the Riasi fault in Indian Kashmir, but it was thought to be less important than other, more active fault systems. However, following a magnitude 7.6 earthquake in 2005 on the nearby Balakot-Bagh fault in the Pakistan side of Kashmir – which was not considered particularly dangerous because it wasn't on the plate boundary – researchers began scrutinizing other fault systems in the region.

They found that the Riasi fault has been building up pressure for some time, suggesting that when it does release or slip, the resulting earthquake may be large – as much as magnitude 8.0 or greater.

“What we set out to learn was how much the fault has moved in the last tens of thousands of years, when it moved, and how different segments of the fault move,” said **Yann Gavillot**, lead author on the study who did much of the work as a doctoral student at Oregon State University. “What we found was that the Riasi fault is one of the main active faults in Kashmir, but there is a lack of earthquakes in the more recent geologic record.

“The fault hasn't slipped for a long time, which means the potential for a large earthquake is strong. It's not a question of if it's going to happen. It's a matter of when.”

Chris Goldfinger

GSA Kirk Bryan Award

Internationally recognized earthquake expert Chris Goldfinger and his coauthors were awarded the 2016 Kirk Bryan Award of The Geological Society of America for their outstanding paper detailing the earthquake history of the Cascadia Subduction Zone. Established in 1951, the Kirk Bryan Award is the oldest and most prestigious of the GSA Quaternary Geology and Geomorphology Division's awards, sometimes known as the Nobel Prize of Quaternary Geology.



International Ocean Discovery Program investigates North Sumatra subduction zone for earthquake potential

A team of scientists embarked on an International Ocean Discovery Program (IODP) expedition to investigate earthquake and tsunami behavior of the North Sumatra subduction zone – a little-understood stretch of continental margin that was responsible for the December 2004 magnitude >9 earthquake that struck North Sumatra and triggered a deadly tsunami. The team, which includes Professor **Marta Torres** with the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University, spent 56 days at sea coring, sampling and characterizing the sediments, fluids and crustal rocks entering the system to understand its earthquake potential.

The sediments offshore North Sumatra are exceptionally thick due to the Bengal-Nicobar submarine fan sediment system that has developed over tens of millions of years from erosion of the Himalayas. This ocean drilling expedition will for the first time drill scientific boreholes within the sediments entering this subduction zone, including the layer of sediment that eventually develops into the earthquake-generating fault.

While researchers know that the sediments originated from the land, still unanswered is how they evolve as they become physically and chemically altered and build up to 4-5 km thick before reaching the subduction zone. Increased burial depth and temperatures also affect fluids within the sediment pile, which are critical to earthquake fault behavior and to how the sediments accrete onto the continental margin.

Scientists suspect that the amount of fluids trapped within the sediment plays a key role in earthquake generation. Torres will apply her expertise in pore fluid geochemistry to analyze fluids for their composition and migration pathways. Understanding these pathways could explain the margin's unusual structure and morphology and its potential to generate fluids before and after subduction, which may define conditions of earthquake generation. Ultimately, the team hopes to understand the hazard potential for this margin, and eventually others with similar material properties and margin morphology.



Academic Programs

Undergraduate Programs

The college is committed to delivering outstanding undergraduate education that prepares tomorrow's science professionals. Bachelor of Science degree programs in Earth Sciences and in Environmental Sciences provide the foundation for diverse careers that apply environmental science, geography, geology and earth system science in consulting, management, education, planning and research.

The majors provide a broad foundation in basic sciences and specialization through diverse options. All students complete practical, experiential learning through a combination of field courses, internships and research experience. The college also serves thousands of undergraduates through minor and provision of general education courses.

CEOAS undergraduates engage in a wide range of research through specialized programs such as Increasing Diversity in Earth Sciences, Research Experience for Undergraduates and through working directly with CEOAS faculty on projects. Research positions for undergraduates are frequently written into federal grant proposals by faculty.

Earth Sciences

The Earth Sciences Bachelor's degree has options in Climate Science, Geography, Geology, and Ocean Science. A full major in Geography and Geospatial Sciences is expected to be available in 2017. All of the options emphasize and incorporate field experiences early on.

The Climate Science option is built on a strong foundation of physical climate system science as well as an emphasis on the intersection of climate with biological, social, political and economic systems. Climate scientists collect data in locations ranging from the poles to the tropics, study satellite and ice core records, and perform simulations of the future climate using advanced computer models.

The Geography option is designed for students interested in the interaction of society with natural processes and resources. A particular strength lies in the application of spatial techniques, such as GIS and remote sensing to explore coupled human-natural system interactions

The Geology option is designed for students with an interest in understanding earth processes, from deep causes of earthquakes and volcanoes to surface processes and climate change in the present and past. Geology students take two separate field courses throughout their degree, one two weeks long and another a month long.

The Ocean Science option is intended for students who are interested in the marine environment, from coastal mangroves in the tropics to the ice-covered Arctic Ocean, and how it interacts with and influences planet Earth. The field course for Ocean Science includes ship time on a research vessel.

Environmental Sciences

The Bachelor's degree in Environmental Sciences encompasses the most diverse range of science options. It is designed for students who have a broad range of interests in the natural environment and the interaction of humans with the environment. Students sample courses in diverse colleges and departments, and may earn their degree on campus or through our Ecampus program. The Environmental Sciences program requires that each student complete a minimum of 3 credit hours of experiential learning related to environmental sciences.

Once students have identified their desired area of focus for the Environmental Sciences they choose an area of specialization in line with their academic interests and career goals. There are nine specialization options available.

Certificates

Oregon State University offers an undergraduate certificate in Geographic Information Science. Geographic Information Science ("GIScience") is a discipline that combines theory and principles underlying:

- geospatial data collection
- technologies to manage, analyze and visualize geospatial data
- computational, statistical and mathematical methods to analyze and model geospatial
- digital cartography and geovisualization (the science and practice of creating maps); and
- cognitive, social and environmental implications of GIScience

Field Experiences

All of the CEOAS undergraduate degree programs require a substantive field or internship experience that helps students explore hands-on learning opportunities most appropriate for their future goals. The following are the field courses required for the various Earth Sciences Options:

- Observing Climate (ATS 295)
- Intro to Geographic Field Research (GEOG 295)
- Introduction to Field Geology (GEO 295)
- Advanced Field Geology (GEO 495)
- Introduction to Field Oceanography (OC 295)

Graduate Programs

The college prepares students to explore, develop original research, and find innovative approaches to the complex questions in earth, ocean and atmospheric science at regional-to-planetary scales. The college builds upon a strong tradition of analytical and computational technology merged with collection of field data to enable a wide range of fundamental and applied research. The ~200 graduate students interact with over 100 faculty to build new approaches to research, teaching, publishing and outreach.

Our graduate students are an important member of the college's research and teaching enterprise. Students gain practical experience working side-by-side with their advisors in a world-class environment. Graduates depart the program with an interdisciplinary understanding of the Earth system and a strong technical knowledge of their field. Employment data indicates a strong demand for these graduates in both the private and public sectors.

Geography

Geography is the study of human use and interaction with the Earth and the identification of spatial and temporal variation in natural and human processes. The program has an applied orientation with three areas of excellence: 1) geospatial technologies and analysis; 2) water, climate and society; and 3) resources, planning and hazards.

Geology

Geology research addresses interactions of the solid Earth with the biosphere, atmosphere and hydrosphere in the past and today. Students pursue research ranging from study of the Earth's interior to paleoclimate, natural hazards, tectonics and Earth resources. The college has extensive analytical facilities in support of geochronology and geochemistry.

Ocean, Earth, and Atmospheric Sciences

The OEAS degree is an interdisciplinary program, integrating biological, chemical, geological and physical approaches to understanding the ocean and atmosphere. Areas of specialization include atmospheric sciences, biological oceanography, chemical oceanography, geological oceanography, geophysics and physical oceanography.

Marine Resource Management

Marine Resource Management (MRM) is a science-based, interdisciplinary master's program that combines the study of biological and physical science of the marine environment with the study of the social, economic, legal, educational and political processes that govern human uses of marine and coastal resources. Graduates from the program are trained to bridge the gap between science and policy.

Certificates

The College offers certificates at the graduate level for Geographic Information Science (see description under Undergraduate section for details) and Water Conflict Management and Transformation. The Water Conflict certificate is an 18-credit interdisciplinary certificate program. It is designed to provide graduate students, non-degree students, water professionals and decision-makers with the required specialized resources and skills to address the water demands and challenges of the 21st Century

Field Experiences

CEOAS offers a number of graduate field courses which provide a unique opportunity to experience Earth science by visiting and exploring the wonderful state of Oregon. Incoming geography students spend six days in the field while being introduced to a wide range of topics using Oregon's diverse geography. Students entering the program studying geomorphology and landscape ecology participate in a four-day course held in HJ Andrews Research Forest where they learn to formulate and test multiple hypothesis about landscape-scale interactions among ecological and geomorphic processes. Other field courses explore the Cascades and Coastal range or deep-dive into differential calculus, integral calculus, ordinal and partial differential equations and vector calculus while connecting mathematics to the Earth sciences.

- Field Geography of Oregon (GEO 534)
- Field Research in Geomorphology and Landscape Ecology (GEO 548)
- Cascadia Field Course (OEAS 500)
- Oregon Coast Math Camp (OC 515)

New Faculty



Christo Buizert has been appointed as an assistant professor. His research focus includes paleoclimate, ice cores, climate dynamics, atmospheric trace gas evolution, climate modeling and firm processes. He combines fieldwork and ice core measurements with numerical modeling to advance our understanding of climate change in past, present and future. Buizert received his Ph.D. in geophysics from the Niels Bohr Institute at the University of Copenhagen, Denmark.



Jennifer Fehrenbacher has been appointed as an assistant professor in tracer oceanography. She was previously a project scientist and lecturer in the Department of Earth and Planetary Sciences at the University of California, Davis. Her research includes the use of geochemical data from microfossils to understand changes in the Earth's climate. Fehrenbacher received her Ph.D. from the University of Chicago, Department of Geophysical Sciences in 2010.



David Rupp has been appointed as an assistant professor. His research focuses on the intersection of climate variability and change, and their influence on the present and future of water resources. Rupp received his Ph.D. in water resources engineering from the Dept. of Biological and Ecological Engineering at Oregon State in 2005. He has worked in CEOAS as a research associate in the Oregon Climate Change Research Institute since 2011. He previously was a research associate with the Cooperative Institute of Marine Resources Studies in Newport, Ore.



Andrew Thurber has been appointed as an assistant professor in ocean ecology and biogeochemistry — a joint appointment between the College of Earth, Ocean, and Atmospheric Sciences and the Department of Microbiology in the College of Science. Thurber's research explores how deep-sea and polar communities function, with a particular focus on identifying how microbial processes are impacted by multicellular animals, especially in soft sediment habitats. He earned his Ph.D. in oceanography from Scripps Institution of Oceanography, UC San Diego, in 2010.



Greg Wilson has been appointed as an assistant professor specializing in sediment transport. Previously, he held a postdoctoral position at Dalhousie University, in Halifax, Canada, where he worked on development and application of broadband acoustical instrumentation. His research involves observation/prediction of nearshore processes and sediment transport using acoustical, remote sensing and data assimilation techniques. Wilson received his Ph.D. in oceanography from Oregon State in 2013.



David Wrathall has been appointed as an assistant professor in natural hazards. Previously, he was an associate academic officer with United Nations University – Institute for Environment and Human Security, where he focused on the nexus of climate change impacts, livelihood systems and human migration. Wrathall received his Ph.D. from King's College London, Department of Geography in 2011.



Bo Zhao has been appointed as an assistant professor in cartography and geovisual analytics and joins the university from Harvard Kennedy School. He has developed methodologies to interpret and visualize human behavior through geospatial big data, in particular geo-tagged Twitter and social media, with respect to public policy, environmental governance and social justice. He received his Ph.D. in geography from Ohio State University in 2015.

