



# AOS & CICS Newsletter

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## CICS Research Internship Program Broadens Participation in Climate Science

This summer, the Cooperative Institute for Climate Science (CICS) in collaboration with NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) recruited both undergraduate and graduate students for 8-10 week paid research internships in atmospheric, oceanic and earth system science. The program, a new venture intended to broaden participation in climate science, matched students from diverse backgrounds with a GFDL/AOS host to work on a focused scientific problem, while benefiting from the resources and activities at GFDL.

Projects were solicited from GFDL staff and the CICS Research Internship Committee, comprised of GFDL Research Oceanographer John Dunne, Jasmin John, a GFDL physical scientist, and AOS Faculty Members Sonya Legg, Yi Ming, and Gabe Vecchi. Research areas included: biogeochemical processes in Earth system models; changing climate extremes; command line interface software; ocean ecosystems model/data comparison; model representation of methane; and extreme weather events. The committee selected the final group of nine interns in conjunction with feedback from project hosts, who were also asked to identify graduate students or postdocs as secondary mentors who would be willing to assist the interns in navigating the Princeton/GFDL culture.



2016 CICS Summer Interns: (Back Row L to R) Aria Alexander, Claire Miles, Miguel Moravec, Leonardo Rodriguez (Front Row L to R) Maryam Abdi-Oskouei, Alyssa Stansfield, Alice Nadeau, Maria Pulido-Velosa, Arieck Norford

“We particularly encouraged applications from students who have not previously had the opportunity to experience scientific research environments, including students at colleges and universities without research programs, and students whose participation will add to the diversity of researchers in earth system science, including first-generation college students, and students from underrepresented groups,” said Legg, associate director of CICS. “Our primary mission in creating the program was to improve the pipeline for underrepresented students in STEM disciplines.”

The summer experience included interaction with scientists and graduate students, access to high performance computing and library facilities, and opportunities to participate in a wide range of seminars and lab social events in a rich research environment. “In addition to conducting research, the interns attended seminars, tutorials and workshops, as well as social events such as group lunches and picnics,” said Jasmin John, who coordinated much of the summer program.

### Program in Atmospheric and Oceanic Sciences (AOS) & The Cooperative Institute for Climate Science (CICS)

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TigerTransit/Shuttle Services Operating on Fall Schedule: <http://www.princeton.edu/transportation/troutes/ForrestalF2016.pdf>

To facilitate connections among interns and their scientific colleagues, the research mentoring experience was supplemented by a Python tutorial; a tour of GFDL's Data Center; a Q&A session on graduate school organized by Legg, Larry Horowitz, an AOS faculty member, and Ming; journal club and science presentations coordinated by AOS Postdoctoral Research Associate Natasha Henschke; picnics and cookouts sponsored by the GFDL Employee Association (GFDLEA); in addition to coordinated lunches between interns and project hosts and mentors, who not only provided insight into the breadth and technical details of scientific projects, but also explored the broader impact of scientific discovery.



(L to R) CICS Interns Aria Alexander, Claire Miles, Alyssa Stansfield, Miguel Moravec

“Working at GFDL has not only given me a glimpse into the work that is being done by the scientists, but it has also given me the opportunity to utilize GFDL’s advanced climate models and further my computer programming skills,” said CICS Intern Alyssa Stansfield, a Rutgers undergraduate who worked with Xiaosong Yang (UCAR, NOAA/GFDL) on a project that looks at ENSO’s effects on extra-tropical storms and weather extremes in the Northern Hemisphere. “The internship is a great opportunity for undergraduate students who think that they may want to pursue a career in scientific research.”

In addition to gaining hands-on experience in the lab and learning the use of a variety of technologies for carrying out research, John said that “as the internship progressed, the hope was that each intern would form a mentoring network as hosts assisted with identifying others at GFDL and Princeton who could provide advice and mentoring on a variety of topics relevant to the intern.”

“Aside from affording me real world experience in coding and data analysis, working side by side with professional scientists has left me with a much more confident perspective on what it means to lead a career in climate-related fields,” said CICS Intern Miguel Moravec, a Vanderbilt undergraduate who worked with Seth Underwood (Engility, NOAA/GFDL) and his team to automate data analysis and figure generation for parts of the North American Multi-Model Ensemble, specifically focusing on subsurface temperature anomalies and atmospheric variations in the Pacific Ocean. “Also working with actual observation data/extremely high-resolution GCM data is really cool.”

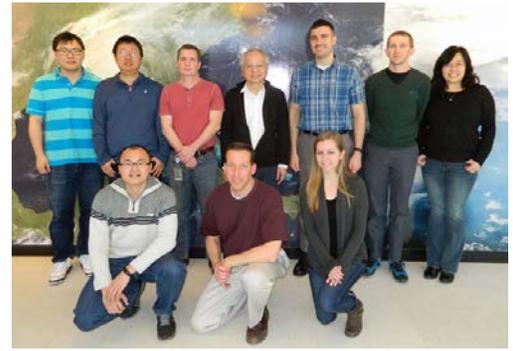
At the end of the summer session, interns presented a 12-minute presentation to the GFDL/AOS/CICS community and provided a summary on their research project to their host. The program will continue again next year, building on the success of its inaugural year. ■

## FV3 to Help Revolutionize NOAA’s Weather Forecasting

**Contributed by Maria Setzer, GFDL Communications Director**

On July 27, 2016, NOAA announced the selection of GFDL’s [Finite-Volume Cubed-Sphere dynamical core \(FV3\)](#) as the basis of a new state-of-the-art global weather forecasting model, to replace the 35-year-old U.S. Global Forecast System (GFS). Building the world’s best global weather model is a high priority for NOAA.

FV3 was developed by a [team of scientists](#) from GFDL and AOS, led by S.J. Lin, group leader, Weather and Climate Dynamics at GFDL. It brings together unprecedented high precision simulation software and numeric efficiency to generate a more accurate description of atmospheric processes, such as cloud formation and movement. This makes possible high-resolution simulations of storms not yet used in an operational global model.



Back row (L to R): Xi Chen (AOS associate research scholar), Zhi Liang (GFDL), Rusty Benson (GFDL), Shian-Jiann Lin (AOS alumnus), Matthew Morin (GFDL), Lucas Harris (former AOS postdoc) and Jan-Huey Chen (former AOS postdoc) Front row (L to R): Linjiong Zhou (AOS postdoc), Timothy Marchok (GFDL) and Shannon Rees (GFDL)

FV3 has been used at GFDL for climate models for a decade, and it has been undergoing continuous improvements and enhancements since it was first developed. It is now mature and ready to be used to improve the GFS. “NOAA’s selection of FV3 for the GFS represents the coming together of climate and weather modeling, which will enhance short-term forecasts and long-term climate prediction,” according to Lin.

FV3 enables a model to monitor and provide forecasts for several weather systems simultaneously, while generating a global forecast every six hours. Looking 10 years ahead, the GFS model with the FV3 core will run in higher resolution and be able to zoom in on smaller and smaller storm systems to provide forecasters better pictures of how storms will evolve.

The new global model will continue to be called the GFS. As with the current GFS, the new GFS will run in the background of NOAA’s suite of weather and climate models improving skill across all NOAA’s forecast mission areas. Goals for the new model include generating better forecasts of hurricane track and intensity, and eventually extending weather forecasting to 30 days.

“Using our powerful supercomputers, our new dynamic core which drives the model, and the newest modeling techniques, we are poised to develop and run a more accurate and reliable global model that we can build on for decades,” said Louis W. Uccellini, director, NOAA’s National Weather Service.

NOAA plans to engage the meteorology community during model development and improvement. The agency plans to develop a program to involve researchers in testing and improving algorithms, data assimilation methods and physics. NOAA hopes this will allow the agency to incorporate successful enhancements into operations and to expedite future model improvements.

Building the next generation GFS will take a tremendous amount of testing, analysis and verification. Model components, including the physics package, data assimilation package and post processing -- all parts of the existing architecture -- will be rebuilt and improved to work with the new software. The new GFS is projected to go operational in late 2019.

The selection of FV3 was the culmination of a process that began in August 2014. NOAA formed a committee of experts from multiple institutions, to evaluate and test the suitability and readiness of five "next generation" candidate dynamic cores, to meet operational forecast requirements at the National Weather Service through 2025-30. Performance and scalability benchmarks were conducted during two sessions on Edison, a 130,000 processor core supercomputer at the U.S. Department of Energy's National Energy Research Scientific Computing Center in March and April 2015. Based on test results, the committee recommended FV3. ■

## AOS Kicks Off the Academic Year with Retreat

For the fifth consecutive year, AOS graduate students, postdocs, research staff, and faculty gathered at Mountain Lakes House in Princeton to mark the start of the academic year. The annual event, one of the most interactive and well-attended activities within the academic year, fosters a sense of community as returning students, research staff, and faculty welcome new students to the Program. The retreat was held on Tuesday, September 13<sup>th</sup>.

With blue skies overhead and nearly 45 people in attendance, organizers of this year's retreat introduced various stations

featuring a balance of self-guided and group science and teambuilding activities with the hope of developing collegiality and friendships that would last far beyond the day's end. Water Chemistry, where participants used a freshwater chemistry kit to measure pH, nitrate, dissolved oxygen, phosphate, and chlorine levels in Palmer Lake; Tower Construction, a team-building activity in which groups used simple materials to construct towers; and Jumble Scavenger Hunt, which involved scrambled word clues hidden throughout the property, were among the morning exercises. Two additional stations Egg Drop Vessel and Water Wheel were crowd favorites, according to retreat organizers. For the first activity, participants were asked to design and construct a vessel out of limited materials (e.g., balloons, newspaper, tape, straws) that could protect an egg when dropped from a height of the group's choice.



*Former AOS Graduate Student Jeff Strong holds the vessel, constructed by his AOS team members, for the Egg Drop Challenge.*

"Designs included a 16 foot long newspaper chute and balloon parachutes," said AOS Graduate Student Aaron Match, a retreat co-organizer. "Successful launch sites escalated throughout the day, from climbing trees, to climbing trees while launching the balloon with a kayak paddle, to the winning group's clandestine launch site that involved slate."

Water Wheel, also a crowd pleaser, used a chaotic Lorenz water wheel that was constructed for the event. Consisting of six leaky cups attached to a freely-rotating bike wheel, the Lorenz water wheel is a physical model of the chaotic Lorenz equations. Participants collaborated to populate a phase diagram of the water wheel behaviors as a function of the flow rate and angle of the apparatus.



*L to R: AOS Research Specialist Nathaniel Tarshish and AOS Graduate Students Spencer Clark and Rob Nazarian look on as AOS Postdoc Seth Bushinsky stabilizes the water wheel.*

Over lunch, members of the AOS community were free to kick back with friends, both old and new, many of whom who played Kubbe, a Viking lawn game which was introduced at the 2014 AOS Retreat. Throughout the day, the new students and faculty exchanged notecards in an informal and interactive exercise to get to know one another.

The early afternoon brought with it a game of charades and trivia, designed to familiarize the participants with members of the faculty and their research and to encourage camaraderie among the players. A subsequent light-hearted session tasked participants with the challenge of designing a "funny product" that would be a lucrative investment in ten years due to climate change and pitching it to their "venture capitalists" colleagues. The winning group promoted an underwater property investment that could be developed following uplift of the Greenland coastline with the tagline "Make Greenland Green Again." Other ideas included Eco-fashion, harnessing congressional hot air as a renewable energy source, occupying the water management secrets of Holland, and an environmental lifestyle app. If the intent was to encourage creative thinking and induce laughter, the session was an enormous success, according to many in attendance.

"The retreat was a wonderful experience, combining both fun and knowledge," said Yi Zhang, a first-year student. "It was a pleasant surprise to me that so many faculty members actively participated in the retreat alongside of students and postdocs, making it an unforgettable experience."

The credit for the success of the 2016 retreat goes to an organizational committee comprised of graduate students, faculty members, and staff who oversaw the planning and implementation of the retreat, including science and social activities. In addition to Match, committee members included AOS Graduate Administrator Anna Valerio, AOS Graduate Students Justin Ng and Sarah Schlunegger and Faculty Members Stephan Fueglistaler and Steve Garner, who served on the committee every year since the inaugural event in 2012.

“The creative thinking inherent to scientific exploration is often practiced alone or in small groups,” Match said. “By orienting the AOS Retreat around a series of challenges that required team-based creative thinking, we hope that we increased the respect that AOS members have for their colleagues’ creative capabilities, with mutual respect the bedrock for future friendships and collaborations.” ■

## Isaac Held Honored by AGU

AOS Faculty Member Isaac Held, a senior research scientist at GFDL, will present the 2016 Jacob Bjerknes Lecture at the American Geophysical Union (AGU) Fall Meeting, being held December 12-16, 2016 in San Francisco. The lecture will take place on Tuesday, December 13 at 8:00 am.



*AOS Faculty Member Isaac Held*

Established in 1993, the Bjerknes Lecture, awarded annually, is one of the two most distinguished named lectures of the Atmospheric Sciences Section of AGU and is given by a prominent scientist in honor of the memory of Meteorologist Jacob Bjerknes, credited with determining the link between El Niño and the Southern Oscillation. Held’s lecture is titled, “Climate Models and Tropical Cyclones: A Hierarchy of Idealized Models of Tropical Cyclogenesis.” Starting with a global atmospheric model that captures many aspects of the climatology of tropical cyclones, a hierarchy of models will be described in which the boundary conditions and geometry of this global model are simplified in an attempt to shed some light on fundamental questions regarding tropical cyclogenesis.

Held’s research interests include atmospheric and oceanic fluid dynamics; geophysical turbulence; climate dynamics; and climate change. He has worked on problems related to fundamental constraints on the structure of the tropical circulation, including the structure of the Hadley circulation, on tropical-extratropical interactions, mid-latitude storm tracks, and the factors controlling the transient and equilibrium response to increasing CO<sub>2</sub> in the atmosphere. Some of his more recent work is focused on tropical cyclones, trying to understand the factors that control the frequency and preferred locations for storm genesis, its interannual variability, and its response to global warming.

Held will be among those recognized at the 2016 AGU Honors Tribute to be held December 14 in San Francisco. He joins an esteemed group of former Bjerknes Lecturers, including former AOS Senior Scientist Kirk Bryan (1993) and Syukuro (Suki) Manabe (1995). For the full list of past lecturers, see:

<http://atmospheres.agu.org/awards/bjerknes-lecture/>. ■

## Frazer Awarded PEI-STEP Fellowship

The AOS Program’s Michelle Frazer is among four graduate students to have been awarded a 2016 PEI-STEP by the

Princeton Environmental Institute (PEI). Selected from a competitive pool of applicants, Frazer will join fellow 2016 Awardees Alexander Berg (Electrical Engineering), Da Pan and Siyuan Xian (Civil and Environmental Engineering) in exploring policy dimensions and implications of their doctoral research through supplementary course-work and policy-oriented research over the next two years.



*AOS Graduate Student Michelle Frazer*

Under the advisement of Michael Oppenheimer (Woodrow Wilson School) and Robert Socolow (Mechanical and Aerospace Engineering), Frazer will focus her research on the policy and environmental implications of one geoengineering strategy known as stratospheric aerosol albedo modification or SAAM, which is designed to help cool the planet by increasing Earth’s albedo.

Frazer proposes to analyze the international policy implications of regional climate impacts of SAAM. “This will require a scientific analysis of possible impacts and their likelihood, which will then frame policy questions regarding the possibility, character, and governance of injecting aerosols into the stratosphere to reflect more solar radiation back into space,” Frazer said.

Because SAAM is likely to have unequal regional impacts, and projections suggest that an attempt to restore a pre-industrial global mean temperature would have unintended climate effects, including reductions in precipitation, it is a controversial method of mitigating climate change.

“Since the use of SAAM is unlikely to disappear quickly from climate discussions, ethical norms and governance

processes ought to be established preemptively, requiring a better scientific understanding to frame the deliberations,” said Frazer.

Frazer, whose thesis adviser is AOS Faculty Member Yi Ming, a 2001 PEI-STEP fellow, is broadly interested in the role of clouds in the climate system. She uses idealized and complex atmospheric general circulation models to isolate physical mechanisms connecting moisture distributions and clouds and to improve understanding of cloud effects.

“My STEP project will allow me to take my current work exploring controls of tropospheric water vapor and clouds and expand my focus to the stratosphere. As my interest in science is motivated by its people-oriented policy implications, I am very excited and honored for this opportunity to meld my scientific and policy interests,” Frazer said.

Frazer joins an impressive group of PEI-STEP fellows, many of whom have gone on to pursue positions of environmental leadership in academic, government, nonprofit, and industry sectors following their time at Princeton, including former AOS Graduate Students Curtis Deutsch and Ian Lloyd who were awarded the Fellowship in 2000 and 2009 respectively, former Geosciences Graduate Student Bryan Mignone who was awarded the Fellowship in 2001, former AOS Graduate Student Joe Majkut who was awarded the fellowship in 2011, former AOS Graduate Student Geeta Persad who was awarded the fellowship in 2013, and current AOS Graduate Student Jane Baldwin who was awarded the fellowship in 2015.

Funding associated with Frazer’s fellowship is provided by the Thomas Jefferson Perkins Class of 1894 Graduate Fellowship fund. ■

## A QUEST to Improve Science Education in Schools

In July, the Cooperative Institute in Climate Science (CICS) co-sponsored a weeklong summer institute in weather and climate for 11 teachers of grades 3-8,

hosted by the University’s Program in Teacher Preparation. The program, whose formal name is Questioning Underlies Effective Science Teaching (QUEST), is designed to enhance teachers’ content knowledge and their skills through hands-on experiments and discussion, emphasizing self-directed investigation rather than textbook learning.

Led by Steve Carson, a middle school teacher and former researcher at the Geophysical Fluid Dynamics Laboratory (GFDL), teachers worked together to better understand the Coriolis Effect, which explains how rotation of the Earth affects winds and ocean currents. Using water bottles placed atop of a turntable modeling Earth’s rotation, teachers used their prediction skills to determine how water would flow from holes in the bottles based on the direction the turntable was spinning. Other experiments focused on air pressure, temperature, the seasons, the greenhouse effect, humidity, clouds, wind and storms.



*Under the guidance of Instructor Steve Carson, QUEST participants conduct an experiment demonstrating the Coriolis Effect.*

According to Anne Catena, program associate and director of professional development initiatives in Princeton’s Program in Teacher preparation, participating teachers learned about the work of researchers and how to translate it for their classrooms, in line with the Next Generation Science Standards being implemented in New Jersey schools this fall. Developed by states, the standards set new expectations for what students should know and be able to do, and are designed to improve science education for all students.

In addition to enhancing participants’ knowledge, the QUEST program aims to inspire new ways to present material to students. “It’s very exciting for kids to know the applications of what they’re

learning in the classroom, and it’s motivating for their teachers, too,” said Catena, noting that the Next Generation Science Standards put an emphasis on student self-discovery. “In QUEST, teachers generate questions themselves but also think about how you get students to start asking questions.”



*Participants get hands-on experience in QUEST classroom.*

The teachers also planned Next Generation Science Standards aligned lessons and engaged in practices such as developing and using models, analyzing and interpreting data, and asking questions and defining problems. New skills, enhanced content knowledge, and hands-on explorations with fellow teachers enable QUEST participants to return to their classrooms with renewed enthusiasm for science instruction. The weather and climate track, which was co-facilitated by Martha Friend, Princeton Township Public Schools, and Donna Stumm, Flemington Raritan School District, drew teachers from eight New Jersey school districts: Hillsborough, Montgomery, North Hanover, Northern Burlington, Somerset Hills and West Windsor-Plainsboro.

In addition to CICS, co-sponsors of the event include the National Science Foundation (NSF) and the Program in Teacher Preparation. A second track focusing on life in extreme environments was sponsored by the Department of Geosciences and was led by Tullis Onstott, professor of Geosciences.

The summer institute took place July 15-20, 2016. ■

## Trugman Named Recipient of Walbridge Fund Graduate Award

AOS Graduate Student Anna Trugman has been named a recipient of the Princeton Environmental Institute (PEI) Walbridge Fund Graduate Award in support of her dissertation research at Princeton. She was selected to receive the award for her proposal, *Assessing Forest Growth, Resilience, and Carbon Accumulation in the North American Boreal Forest: Integrating Remote Sensing and Field Measurements with Models*.



AOS Graduate Student Anna Trugman

Boreal forests currently contain over 30 percent of Earth's terrestrial carbon. However, the future of these high-latitude forests is uncertain due to increasing air temperature, hotter drought conditions, and changes in fire regime and insect disturbance. Anna Trugman, an AOS graduate student, is working to elucidate the future resilience of the boreal forest carbon sink by refining predictive models of how these forests will respond to global change.

"My doctoral dissertation focuses on improving our understanding of the mechanisms that control tree growth and mortality and soil carbon accumulation in the boreal forest. Through an approach that integrates diverse measurements scaling from the level of tree to landscape with numerical vegetation models, I hope to develop more accurate predictive models that will help us understand how global change will affect high latitude forests," said Trugman.

Her current research focuses on incorporating important drought legacy mechanisms that affect tree growth and mortality within numerical models. This will better enable models to reproduce observed tree growth declines and increases in tree mortality in many parts of the Canadian and Alaskan boreal forest.

"This work is crucial for assessing the boreal forest response to global change and for developing forest management strategies in the upcoming century," said Trugman. "It will enable us to better predict how the boreal ecosystem and the global carbon cycle as a whole will be affected by global climate change."

In addition to Trugman, four other Princeton graduate students were selected to receive the award, including Cara Brook (EEB), Victor Charpentier (CEE), Jennifer Kasbohm (Geosciences) and Yuzhen Yan (Geosciences). Their research addresses important issues in climate change including emergence of zoonotic diseases, biomimetic building design, and perturbations in Earth's climate history, respectively.

Initiated in 2009, the PEI Walbridge Fund has provided support to Princeton graduate students pursuing innovative projects in the fields of energy technology, carbon policy, and climate science. Trugman is the first AOS graduate student to receive the Walbridge Fund Award since its initiation. The awards are selected by a committee of Princeton faculty based on the quality of the proposed research, strength of faculty letters of recommendation, proven student accomplishments (peer-reviewed publications and awards), and financial need for independent research.

Funds from the Walbridge Award will enable Trugman to present her research at the Ecological Society of America Annual Meeting and the American Geophysical Union Fall Meeting. ■

## AOS Pub Crawl Builds Community

On Friday, September 23<sup>rd</sup>, members of the AOS community took part in the fourth annual AOS Pub Crawl, a growing tradition organized by graduate students to ring in the new academic year. The event

coincided with AOS Graduate Student Jaya Khanna's successful Final Public Oral (FPO) examination earlier that morning, lending a celebratory atmosphere to the occasion.

In the evening, AOS scientists, postdocs, and graduate students congregated at the Ivy Inn, a familiar stomping ground to some for weekly trivia night, and made their way to five well known establishments along Nassau Street, socializing and sampling libations along the way. The stops included Triumph Brewing Company, the Alchemist & Barrister (A&B), the Yankee Doodle Tap Room, and Winberie's. The largest crowd was at Triumph, a mainstay in Princeton for more than 20 years, with about 30 people in attendance, according to Nick Lutsko, an AOS graduate student and pub crawl organizer. The turnout for the event would have been even higher, noted Lutsko, had some faculty members, who have attended in past years, not been away on travel.

Many of the new students participated in the crawl and welcomed the opportunity to get to know fellow students and more seasoned members of the research staff in a relaxed, informal setting, in addition to becoming more familiar with downtown Princeton and experiencing the local favorites of returning students.

"Going to the AOS pub crawl was a great way to break the ice with fellow students and postdocs," said Shiv Priyam Raghuraman, a first-year student in the AOS Program. "It set the foundation for many friendships I have made in the Program and gave me the chance to get my apprehensions for the upcoming year cleared by the older students."

As in past years, the event encouraged intermingling and a sense of camaraderie between all those who participated. "Overall, I was happy with how the night turned out," said Lutsko. "I thought it was fun and good natured, and it also helped close the divide between people who work at GFDL and people who work at Sayre."

Organizers hope that the tradition continues into its fifth year as a complement to the departmental retreat, which took place earlier in September. ■

## AOS & CICS

### Research in Action

*[This column is intended to focus on AOS & CICS research accomplishments and milestones, past, present, and future. In this issue, we highlight the accomplishments of AOS Postdoctoral Research Associate Rebecca Asch who spent three years in the AOS Program.]*

Rebecca Asch, a postdoctoral research associate and Nereus fellow who left the Program in mid-September, has been part of the AOS team for the past three years working under the joint supervision of AOS Faculty Member Jorge Sarmiento and Charlie Stock, a research oceanographer at GFDL. As a Nereus fellow, Rebecca's research has focused on how climate change will impact global fisheries production throughout the 21<sup>st</sup> century.



*Former AOS Postdoc Rebecca Asch sporting her AOS sweatshirt, while traveling in Norway following an IMBER conference*

More specifically, Rebecca's research examines how climate change affects the seasonal timing of both phytoplankton blooms and fish reproduction. Many fish species have evolved to spawn at approximately the same time as phytoplankton blooms in order to maximize food availability for larval fish that consume zooplankton that graze down phytoplankton blooms. However, different environmental cues trigger phytoplankton blooms and induce fish to spawn. Although both fish spawning and phytoplankton blooms are expected to occur earlier in the year under a warming climate, these different environmental triggers suggest that these changes may not occur in sync. This could potentially lead

to reduced survival and growth of fish larvae and lower fisheries production, which could in turn impact food security in many regions.

Using the GFDL Earth System Model, Rebecca's postdoctoral research produced the first near-global projections of whether seasonal mismatches between fish reproduction and plankton blooms are likely to increase in the future. This research indicates that such mismatches are projected to increase the most in high-latitude ecosystems that support the world's largest fisheries. However, the extent of such mismatches is moderated by whether fish are able to track climate velocity by migrating northward as the climate warms. Some species may be unable to migrate northward due to their dependence on specific habitats (*e.g.*, rivers, salt marshes, seagrass beds, coral reefs) that have fragmented distributions. Species that do not track climate velocity were subject to greater seasonal mismatches with their prey. When presenting this research at a conference sponsored by the International Council for the Exploration of the Sea (ICES) and the North Pacific Marine Science Organization (PICES) in 2015, Rebecca received an award for the best early career scientist presentation.

In addition to her work on this project, Rebecca had several opportunities to participate in collaborative research projects while at AOS. Through the Nereus Program, a multi-university, interdisciplinary effort examining global changes in fisheries, Rebecca co-authored a report on how to incorporate uncertainty into future projections of changes in living marine resources. Along with collaborators at Scripps Institution of Oceanography, University of South Carolina, University of Texas, and NOAA's Northeast Fisheries Science Center, Rebecca worked on projects investigating the influence of climate change on small pelagic fishes (*e.g.*, sardines, anchovies), projected changes in the distribution and phenology of reef fish spawning aggregations, and interannual variability in the timing of phytoplankton blooms detected via remote sensing. In 2014, Rebecca participated in EcoDAS (Ecological Dissertations in the Aquatic Sciences), a biennial workshop held in Honolulu that aims to generate collaborative research partnerships among recent Ph.D.'s in biological oceanography

and limnology. Through EcoDAS, Rebecca published two manuscripts: one that addressed the need to better incorporate climate variability into experiments designed to identify ecological climate change impacts and a second manuscript that developed an introductory primer for aquatic ecologists interested in starting to work with Earth System Models.

During her time at AOS, Rebecca was highly involved in mentoring and advising undergraduate researchers. Over the last three years, Rebecca has advised four PEI interns, three junior-year undergraduate research projects, and two senior theses. Along with former AOS Associate Research Scholar Greg de Souza, Rebecca co-lead a one-week workshop during which students from Swarthmore College visited Princeton to get hands-on experience analyzing biogeochemical data from Argo floats.

Regarding her experiences at AOS, Rebecca said that she really appreciated being given the freedom to design her own research projects and to explore new directions. "As a fisheries oceanographer who had previously worked mainly with observational data, this has been an especially interesting time in my career since I had the opportunity to interact much more with biogeochemists and physical oceanographers at GFDL and AOS, as well as social scientists involved in the Nereus Program," she said. "This has really expanded my horizons in terms of working in interdisciplinary teams." Rebecca also notes that she will miss the collegiality of everyone at AOS and GFDL, especially the lunches outside at the picnic tables and Friday afternoon teas.

"Rebecca's work is distinguished by its creativity, rigor, and attention to detail," said Stock. "These same qualities are reflected in daily scientific conversations during her time at Princeton and should lead to a long career of lasting contributions in fisheries science and oceanography."

Rebecca is headed to East Carolina University where she will begin a new position in January as an assistant professor of fisheries biology. In the interim, Rebecca will spend a few months in Texas and California where she will be working as a research fellow at the University of Texas at Austin's Marine Science Institute.



# AOS & CICS News

Congratulations to **Spencer Hill** who successfully defended his Ph.D. Thesis, "Energetic and Hydrological Responses of Hadley Circulations and the African Sahel to Sea Surface Temperature Perturbations," on August 2, 2016.

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Congratulations to **Jeff Strong** who successfully defended his Ph.D. Thesis, "The Climatological Effect of Perturbations in Atmospheric Burden and Optical Properties of Saharan Dust," on August 12, 2016.

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Congratulations to **Jaya Khanna** who successfully defended her Ph.D. Thesis, "Regional Hydro-Climatic Impacts of Contemporary Amazonian Deforestation," on September 23, 2016.

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Congratulations to **Todd Mooring** who successfully defended his Ph.D. Thesis, "Transient Eddies in the Martian Atmosphere: Representation in Reanalysis and Idealized Modeling," on September 30, 2016.

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Princeton University researchers have compiled 30 years of data to construct the first ice core-based record of atmospheric oxygen concentrations spanning the past 800,000 years, according to a paper published recently in the journal *Science*. The team included, among others, AOS Associated Faculty Member **Michael Bender**, professor, emeritus.

<https://blogs.princeton.edu/research/2016/09/23/ice-cores-reveal-a-slow-decline-in-atmospheric-oxygen-over-the-last-800000-years-science/>

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## [Radiative Convective Equilibrium as a Framework for Studying the Interaction between Convection and its Large-Scale Environment](#)

A recent paper led by **Levi Silvers**, an AOS associate research scholar, shows that a GCM in Radiative Convective Equilibrium is sufficiently similar across a range of domain sizes to justify the use of RCE to study both a GCM and a high resolution model on the same domain with

the goal of improved constraints on the parameterized clouds. Despite similar climate states between domains, the climate feedback parameter varies by more than a factor of two. This variation is related to both shortwave and longwave cloud radiative effects. The [study](#) was published in the *Journal of Advances in Modeling Earth Systems*.

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## [Recent Study Improves Understanding of Climate of Interior Asia's Vast Deserts](#)

A recent study, led by AOS Graduate Student **Jane Baldwin** and coauthored by **Gabe Vecchi**, an AOS faculty member, improves understanding of the climate of interior Asia's vast deserts through a set of idealized climate model simulations. The authors found that the Tian Shan Mountains (a northern offshoot of the Tibetan Plateau) increase summer precipitation across the east deserts by altering atmospheric circulation to strengthen the East Asian monsoon. While significant literature has discussed the importance of the broad Tibetan Plateau for monsoons, the authors' results indicate a uniquely important role for the Tian Shan in driving this precipitation feature that affects people across East Asia every summer. The [paper](#), "Influence of the Tian Shan on Arid Extratropical Asia," was published in the *Journal of Climate*.

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## [Climate Science Strategy of the US National Marine Fisheries Service](#)

Changes to our climate and oceans are already affecting living marine resources (LMRs) and the people, businesses, and economies that depend on them. As a result, the U.S. National Marine Fisheries Service (NMFS) has developed a Climate Science Strategy (CSS) to increase the production and use of the climate-related information necessary to fulfill its LMR stewardship mission for fisheries management and protected species conservation. The [paper](#) was published recently in *Marine Policy* and was coauthored by **Vince Saba**, an AOS visiting research collaborator.

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Princeton E-filiates Partnership and ExxonMobil announced five collaborative research projects on energy and the

environment ... AOS Research Oceanographer **Alistair Adcroft** and **Olga Sergienko**, an AOS research glaciologist, are lead researchers on a project on Arctic sea-ice modeling.

<http://acee.princeton.edu/acee-news/princeton-e-filiates-partnership-and-exxonmobil-announce-five-collaborative-research-projects-on-energy-and-the-environment/>

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## [Sonya Legg Coauthors White Paper - Translating Process Understanding to Improve Climate Models](#)

The white paper resulting from the USCLIVAR workshop in October 2015 at GFDL on *Translating Process Understanding to Improve Climate Models* is now [published](#). The paper, coauthored by CICS Associate Director **Sonya Legg**, an AOS faculty member, synthesizes the ocean, atmospheric, and climate modeling and observational communities' input on the need for a coordinated effort to translate process understanding into climate model improvements.

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## [Saba Coauthors Chapter on the Impacts and Effects of Ocean Warming on Marine Turtles in a Newly-Released IUCN Report](#)

A newly-released report, *Explaining ocean warming: Causes, scale, effects and consequences*, reviews the effects of ocean warming on species, ecosystems and on the benefits oceans provide to humans. Compiled by 80 scientists from 12 countries, it highlights detectable scientific evidence of impacts on marine life, from microorganisms to mammals, which are likely to increase significantly even under a low emissions scenario. AOS Visiting Research Collaborator **Vince Saba** is coauthor of the chapter that discusses the impacts and effects of ocean warming on marine turtles:

Fuentes, M.P.B. and **Saba, V.S.** 2016. Impacts and effects of ocean warming on marine turtles. In: Laffoley, D., & Baxter, J.M. (editors). 2016. *Explaining ocean warming: Causes, scale, effects and consequences*. Full report. Gland, Switzerland: IUCN. pp. 289-302.

## [The Increasing Importance of Atmospheric Demand for Ecosystem Water and Carbon Fluxes](#)

Soil moisture supply and atmospheric demand both affect vegetation water use and productivity. In an analysis of flux measurements from ecosystems across North America, the authors of a recent [study](#), coauthored by AOS Associate Research Scholar **Benjamin Sulman**, found that physiological responses to atmospheric demand limit surface conductance and evapotranspiration to a greater extent than soil moisture in many biomes, including forests that are of particular importance to the terrestrial carbon sink. Using projections from ten general circulation models, the authors show that climate change will increase the importance of atmospheric demand-driven constraints to carbon and water fluxes. The paper was published in *Nature Climate Change* in September.

## [Vecchi and Murakami Discuss Recent Hurricane Activity](#)

AOS Faculty Member **Gabe Vecchi** and **Hiroyuki Murakami**, an AOS associate research scholar, discuss recent hurricane activity. The [story](#) was published September 2 in *The New York Times*. **Murakami** was also quoted in a WXshift [story](#) published August 30.

## [Alumni News](#)

### [Climate Change Increased Chances of Record Rains in Louisiana by at Least 40 percent](#)

Human-caused climate warming increased the chances of the torrential rains that unleashed devastating floods in south Louisiana in mid-August by at least 40 percent, according to a team of GFDL/Princeton University and partner scientists with World Weather Attribution (WWA) who conducted a rapid assessment of the role of climate on the historic heavy rain event. Former AOS Postdoctoral Research Associate **Karin van der Wiel** led the assessment. The team also included **Sarah Kapnick**, a physical research scientist at GFDL, and AOS Faculty Member **Gabe Vecchi**, among others. The [rapid assessment](#) was submitted to the open

access journal *Hydrology and Earth System Sciences Discussions*, which has an open online peer review process.

## [Sources of Uncertainties in 21st Century Projections of Potential Ocean Ecosystem Stressors](#)

The authors of a recent study, led by former AOS Postdoctoral Research Fellow **Thomas Frölicher** (ETH Zurich), provide a first holistic assessment of the magnitude of changes and the sources of uncertainty in 21st century projections of potential ocean ecosystem stressors at global and regional scales. This has been accomplished by analyzing output from a range of Earth system models that participated in the Coupled Model Intercomparison Project phase 5 (CMIP5). The paper, coauthored by **Keith Rodgers** (AOS), **Charlie Stock** (GFDL), and William Cheung (NF-UBC Nereus Program), was published August 31 in *Global Biogeochemical Cycles*.

<http://onlinelibrary.wiley.com/doi/10.1002/2015GB005338/abstract>

## [Arrivals](#)

The AOS community welcomes new graduate students: **Matthew Gliatto**, **Shiv Priyam Raghuraman**, **Jane Smyth**, and **Yi Zhang**!

**Jordan Schnell** arrived in mid-September from the University of California, Irvine. He is working with Larry Horowitz and Vaishali Naik as a postdoc.

AOS Intern **Seonuk (John) Kim**, an Academy for Medical Science Technology (AMST) high school student, arrived in mid-September. He will be in Sayre Hall on Wednesdays and will work alongside of Bob Key over the next year.

**Maximilien Bolot** will be arriving in early November to work with Stephan Fueglistaler and his group as an associate research scholar.

## [Departures](#)

AOS Associate Research Scholar **Andrew Barton** accepted a faculty position at

UCSD-Scripps. He left the Program in late August.

**Rebecca Asch**, a Nereus fellow and a postdoc in the Sarmiento Group, has accepted a faculty position in the Department of Biology at East Carolina University, effective January 2017. In the interim, Rebecca has been working as a research fellow at the University of Texas at their Marine Science Institute.

**Karin van der Wiel**, an AOS postdoc, has accepted a postdoctoral researcher position at the Royal Netherlands Meteorological Institute (KNMI). She left the Program at the end of September.

AOS Associate Research Scholar **Jingqiu Mao** has accepted a faculty position at the University of Alaska, Fairbanks. His appointment is effective November 1st.

## [Birth Announcements](#)

Congratulations to AOS Associate Research Scholar **Carolina Dufour** and her husband, Laurent, on the birth of their son, Jules, on August 14, 2016.

Congratulations to AOS Postdoctoral Research Associate **Angel Muñoz** and his wife, Catherine, on the birth of their son, Leo Eneko, on August 23, 2016.

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