



# AOS & CIMES Newsletter

Program in Atmospheric and Oceanic Sciences (AOS) &  
The Cooperative Institute for Modeling the Earth System (CIMES)

Fall 2019

Volume 13, Number 3



## AOS Graduate Student Aaron Match, NSF Graduate Fellowship Recipient

What on Earth has a period of 28 months? That's the question atmospheric dynamicists were pondering in the 1960s following the discovery that winds in the tropical stratosphere completely reverse directions with a period of about 28 months. Many of the original questions have been answered, but this quasi-biennial oscillation (QBO) continues to fascinate and challenge - not least because of its outsized effect: The 1 percent of the atmosphere in the QBO region contributes about 10 percent of the total atmospheric momentum variance and even changes the length of the day! (Modestly though - by about 0.1 milliseconds).

*Continued on Page 2*



## CIMES Postdoctoral Fellow Rachel Baker

Climate change is likely to profoundly modulate the burden of infectious diseases. Vector-borne diseases (malaria, dengue) may shift their ranges as temperature or precipitation alters mosquito life cycles; directly transmitted infections (influenza) may intensify as virus survival and contact patterns react to changing humidity and precipitation; environmental transmitted infections (cholera) may be spread by flooding. However, attributing health impacts to a changing climate requires being able to associate changes in infectious disease incidence with the potentially complex influences of climate. This aim is further complicated by nonlinear feedbacks inherent in the dynamics of many infections, driven by the processes of immunity and transmission.

*Continued on Page 3*

## GFDL Completes Successful Lab Review in October

Contributed by Maria Setzer, GFDL Communications Director

In late October, GFDL scientists and many of their CIMES colleagues successfully concluded an OAR-mandated review to evaluate the quality and relevance of research conducted at GFDL. This comprehensive assessment of GFDL's research garnered favorable feedback from a panel of experts who came from institutions such as the National Science Foundation, Pacific Northwest National Laboratory, National Center for Atmospheric Research, Max Planck Institut für Meteorologie, Scripps Institution of Oceanography, University of Tokyo (Japan), and University of Washington.

*Continued on Page 2*

## Welcome!

It is our great pleasure to congratulate former GEO Hess Fellow (now with AOS) Nadir Jeevanjee for receiving the AGU James R. Holton Award; Leo Donner for becoming fellow of the American Association for the Advancement of Science (AAAS); and Jorge Sarmiento for receiving the Theodore Roosevelt Government Leadership Award. On behalf of the AOS Program, we also would like to thank Jorge for his many years of distinguished service as Director of AOS and the Cooperative Institute.

Gabe Vecchi, Director, CIMES.  
Stephan Fueglistaler, Director, AOS.

## Inside this issue:

Aaron Match.....	1
Rachel Baker.....	1
GFDL Lab Review.....	1
Sarmiento Award.....	3
CIMES Internship.....	4
Leo Donner Named AAAS Fellow.....	5
Nadir Jeevanjee Holton Award.....	6
Nereus Conference.....	6
Tsung-Lin Hsieh Bridging Science & Art.....	7
QUEST Summer Institute.....	8
Climate Up Close.....	9
2019 AOS Retreat.....	10
Research in Action.....	12
AOS & CIMES News.....	12

---

### *Aaron Match continued from page 1*

The oscillations in the atmospheric momentum budget are linked to the downward propagation of the oscillating winds, and their eventual vanishing at the tropical tropopause. Working with AOS Director Stephan Fueglistaler, Aaron Match's work sheds light on the processes that form this "buffer zone" at the tropical tropopause. The buffer zone is key to the global momentum budget oscillations, connecting winds high up in the stratosphere with weather in the tropics.

Former AOS student R. Saravanan (Ph.D. 1990, now professor at Texas A&M) showed in a pioneering work that steady upwelling could form a buffer zone. In a paper recently submitted to JAS (1), Aaron showed that upwelling might not be as crucial to buffer zone formation as previously thought. Other plausible dynamical perturbations can form buffer zones. Moreover, depending on the representation of wave dissipation, upwelling might not be able to form a buffer zone at all! In a paper published earlier this year, Match and Fueglistaler showed that in atmospheric reanalyses, horizontal momentum fluxes play a key role in forming the buffer zone, with only modest contributions from upwelling.

What's next? Noting that the QBO buffer zone problem fits with his broader interests of melding theory and observations to understand how dynamics, radiation, and chemistry interact, Aaron continues: "Given the urgency of climate change, the next step is to apply our theoretical insights to understand and better predict the QBO and its interaction with weather and climate in the tropics. The case has been made - with former AOS graduate student and later faculty Kevin Hamilton involved - that global warming has already deepened the buffer zone. Could the story change when our updated understanding of buffer zone dynamics is brought to bear?"

- (1) Match, A., and S. Fueglistaler, "The Effect of Upwelling on the QBO and Formation of the Buffer Zone", submitted to JAS).
- (2) Match, A. and S. Fueglistaler, 2019. "The Buffer Zone of the Quasi-Biennial Oscillation." JAS, Volume 76, 3553-3567. ■

---

### *GFDL Lab Review continued from page 1*

This 3-day review was held at the Taylor Auditorium in Frick Chemistry Laboratory at Princeton University. GFDL scientists, and CIMES and UCAR collaborators, presented an overview of ongoing research efforts and accomplishments since the last review, and the nine members of the expert review panel engaged them in discussion. Attended by over 200 researchers, the presentations focused on the development of next-



*Several members of the lab review panel at Prospect House. Front row, L to R: Tatiana Ilyina, L. Ruby Leung, Anjuli S. Bamzai (Chair). Back row, L to R: William Large, Jean-François Lamarque, Christopher Bretherton, Shang-Ping Xie*

generation models for advancing scientific understanding of the Earth system and for improved predictions and projections across timescales.

Over the course of three days, presentations were categorized into themes: Modeling the Earth System; Advancing the Understanding of the Earth System; and Earth System Predictions and Projections. The first theme, "Modeling the Earth System," showcased recent progress toward developing a unified modeling suite for predictions and projections, on time scales from days to decades. Components of the new modeling system were featured, including FV3 - the dynamical core now used for a wide array of research, prediction, and projection applications. CIMES scientist Alistair Adcroft presented the ocean and ice components. Atmosphere, and land components were also highlighted in this session.

In the afternoon, the focus shifted to the second theme, "Advancing the Understanding of the Earth System", featuring research projects that have strengthened our understanding of the biogeochemical processes that influence the atmosphere, land, and ocean, the sensitivities of those processes to human activities, and the associated feedbacks. Radiative impacts of aerosols and greenhouse gases, land-coastal ocean interactions, future ENSO risks, and interactions between ocean and ice-sheet were among the topics covered. CIMES Associate Director Sonya Legg co-chaired this theme, while CIMES postdoctoral researchers Fabien Paulot, Meiyun Lin, Minjin Lee, Pu Lin, and Olga Sergienko gave presentations.

The second day began with the final theme, "Earth System Predictions and Projections", focused on a seamless, unified modeling suite allowing scientists to address critical problems of predictability and interactions across time and space scales. Presentations underscored the breadth of GFDL research and

modeling in this area. This session highlighted the lab's recent advances in the prediction and understanding of tropical cyclones, hydrological extremes, and the impact of ocean conditions on marine ecosystems. This session was punctuated with talks about Arctic sea ice, seal level rise, and ecosystem prediction. This session featured talks given by CIMES postdoctoral scientists Nat Johnson, Feiyu Lu, and Liping Zhang, a UCAR project scientist.

In addition to the formal presentations, poster sessions highlighted the lab's current efforts. Twenty-five posters covered topics such as future dynamical core development, Water Availability in the Sahel, Subseasonal Prediction, Tropical Cyclone Motion in a Changing Climate, and Precipitation Change from a Deepening Troposphere. CIMES postdoctoral researchers Linjong Zhou, Xi Chen, Nadir Jeevanjee, Xiao Liu, Yujin Zeng, Jian He, Veronica Chan, Kun Gao, Gan Zhang, Andrew Ross, and Sarah Schlunegger, an AOS postdoctoral research associate, were among the poster presenters.

The last review of GFDL was conducted in 2014. Scientific reviews are conducted periodically for each laboratory in NOAA's Office of Oceanic and Atmospheric Research, to evaluate the quality, performance and relevance of research. These reviews help to strategically position laboratories in their planning of future science and are intended to ensure that the research is linked to the NOAA's strategic plan, and remains relevant to the agency's research mission and priorities. ■

### [Rachel Baker continued from page 1](#)

At Princeton, the proximity of the Geophysical Fluid Dynamics Laboratory with expertise in climate sciences, and the Disease Group in the Department of Ecology and Evolutionary Biology creates a unique environment for the interdisciplinary detective work required to characterize how climate drivers shape infectious disease dynamics. A group of talented postdocs with backgrounds from across the sciences, from engineering to economics, is opening the way to confronting and combining models and data of infectious diseases with the best contemporary methods in climate sciences.

Rachel Baker is one of the postdocs in the group. She works with Jessica Metcalf, and is supported by CIMES. With a PhD from Princeton University in the STEP program, Rachel is grounded in classic methods in econometrics. Over the course of her PhD, she became interested in how methods from econometrics could be combined with methods from infectious disease modelling to probe the role of climate drivers in infectious diseases. Her innovative first paper in this area identified climate drivers of chicken pox across Mexico, and revealed a shifting seasonal pattern of burden predicted under a changing climate [1]. This set the stage for further work: her recently accepted paper

on Respiratory Syncytial Virus (in Nature Communications) builds on these methods to provide the first comprehensive window onto the effect of climate drivers on the dynamics of this high burden pathogen across both tropical and temperate locations [2]. Expanding this framework to considering other directly transmitted pathogens is an important next step. Morbidity and mortality associated with influenza continues to impose a significant health burden around the globe. Rachel is currently exploring how climate change will shape influenza dynamics at a global scale.

Refs:

- [1] Baker et al. 2018 Dynamic response of airborne infections to climate change: predictions for varicella. Climatic Change
- [2] Baker et al. Epidemic dynamics of respiratory syncytial virus in current and future climates, Accepted, Nature Communications. ■

## **Sarmiento Recipient of Theodore Roosevelt Government Leadership Award**

Jorge Sarmiento, the George J. Magee Professor of Geoscience and Geological Engineering, Emeritus, was one of 15 recipients of the inaugural Theodore Roosevelt Government Leadership Awards (Teddies) recognized at a gala event on September 19, 2019 at the Washington National Cathedral.



*Far left: Jorge Sarmiento, the George J. Magee Professor of Geoscience and Geological Engineering, Emeritus*

Sarmiento, director of the Southern Ocean Carbon and Climate Observations and Modeling project (SOCCOM), was lauded, by the U.S. Government Executive Media Group, for his directorship of the Cooperative Institute for Modeling the Earth System (CIMES) and its predecessor, the Cooperative Institute for Climate Science (CICS). He was one of three recipients in the "Partners" category, which recognizes government's cross-sector partners whose support and guidance of government initiatives was key to their success.

Government Executive cited Sarmiento's collaborative research with NOAA's Geophysical Fluid Dynamics Laboratory (GFDL), writing: "This unique academic-government partnership is an established world leader in understanding and predicting weather and climate across time scales from days to decades. The foundation for this enduring and impactful public-private partnership was built on a need for building numerical models of the earth's processes for environment applications, requiring individuals to develop highly specific scientific and computer programming skills. Sarmiento has been an inspiring leader in the partnership to advance its weather and climate goals. Through the work of the researchers attracted to Princeton by Sarmiento's scientific acumen, GFDL has become a world leader in developing earth system models, the tools used to predict how climate and environmental systems will change in the future."

In a congratulatory statement, GFDL Director V. Ramaswamy credited Sarmiento with having "successfully forged" the innovative, multi-decade partnership between Princeton and NOAA that allowed them to take on the "tough Earth System Science challenges important to the nation and the world, especially in modeling." Ramaswamy also acknowledged the partnership's outstanding impact on the training of the next generation of scientists in the field. Over 370 scientists have passed through the postdoctoral and visiting research scientist program since its inception and 125 students have earned doctorates through the AOS Program. During his nearly 40 years on the AOS faculty, Sarmiento alone has advised 18 Ph.D. students and 58 postdoctoral researchers, many of whom have gone on to be significant figures in the field.

Sarmiento has been a leading scientist for over four decades, a mentor, and a steadfast leader, embodying the very best of scientific curiosity and inspiring a new generation of scientific thinkers. His leadership has been instrumental to the University's close and historic relationship with GFDL and to the partnership's scientific legacy.

For more information on the Theodore Roosevelt Government Leadership Awards, visit: <https://www.govexec.com/feature/teddy-winners/> ■

## **CIMES Internships Broaden Participation in Earth System Science**

A research internship at an early career juncture can be an incredible stepping-stone for talented students who are deciding whether to pursue a career in scientific research. This summer the Cooperative Institute for Modeling the Earth System (CIMES) offered seven

highly qualified and motivated interns from diverse backgrounds the opportunity to engage in cutting-edge scientific research and to get a glimpse of what their future path might look like.



*Front Row: (L to R:) Mariela Arceo Madriz, Nana Yaa Takyia Afreh, Ana Bolivar Back Row: (L to R:) Alexandra Matthews, Maurizia De Palma, Alex Chang, Nkeh Perry Boh*

The CIMES Research Internship Program, initiated in 2016 under the Program's predecessor CICS, is designed to broaden participation of historically underrepresented groups in Earth system sciences, bridging the gap between NOAA-GFDL, the University, and the wider academic community.

For eight to ten weeks, the students – all undergraduates (although the internship is open to graduate students) – participated in a broad array of projects under the mentorship of their GFDL/AOS host. Projects, spanning the range of research conducted at GFDL, were solicited from GFDL/AOS staff by the CIMES Research Internship Committee and included: an analysis of atmospheric rivers simulated in GFDL 50km resolution AM4/CM4; trends and variability in atmospheric carbon monoxide in GFDL-ESM4; assessing ocean acidification in Earth system models; evaluating the biological carbon pump in a water mass framework; representation of marine organic aerosols in the GFDL Earth System Model; simulated changes of North Atlantic air-sea heat flux feedback in a warm climate; and data access and techniques for large climate model datasets using the Pangeo framework.

The internship afforded the 2019 cohort not only the opportunity to participate in collaborative, hands-on, and closely mentored research at a world-leading center of Earth system modeling, research, and prediction, but also to refine their interests, as they look towards graduate school or the job market. This is particularly important for emerging scholars who may not have these opportunities at their home institution or elsewhere. Spending several weeks in GFDL's collaborative research environment offers unparalleled transdisciplinary interaction and exposure to the computationally intensive approach, often used in climate modeling. The opportunity can have a transformative impact.

2019 CIMES Intern Maurizia De Palma, a rising senior at Kean University who is studying Geosciences with a minor in both Sustainability Sciences and Mathematics, worked with GFDL Physical Scientist John Krasting to analyze anthropogenic carbon uptake and ocean acidification in GFDL's CM4 and ESM4 models. During her summer internship, she gained programming experience and experience working with climate model output, while contributing to the analysis of GFDL's latest-generation models.

"Working with GFDL has not only challenged me but also opened my eyes about the delicate and intertwined nature of the various Earth systems," De Palma wrote in the NOAA EEO/Diversity Program Office Newsletter. "It is rewarding to creatively represent data that can be used to inform environmental awareness and policies to help make the world a better place."

De Palma is planning on continuing collaboration with Krasting this academic year where she will continue analyzing additional historical simulation ensemble members of ESM4. She has submitted an abstract to the AGU Fall Meeting and plans to present her research this spring at a Kean University research event.

Mariela Arceo Madriz, a 2019 CIMES intern and a 5<sup>th</sup> year student enrolled at the University of California, Merced, majoring in Environmental Engineering, explored Marine Organic Aerosols (MOA) with GFDL Physical Scientist Fabien Paulot, learning about "their emissions, spatial and seasonal distribution, and how uncertainties in their representation can affect climate projections." The research performed during her CIMES internship will prove invaluable in advancing the representation of MOA in GFDL models, according to her mentor.

"I have been challenged and encouraged," she said, referring to Paulot and the entire GFDL community, who opened their doors to her for questions and discussions. "I am very grateful to have this experience, and I would encourage all students interested in STEM to apply."

Happy to have accepted a 2019 Internship, Nkeh (Perry) Boh from Bronx Community College evaluated innovative data access and techniques for large climate model datasets, in particular the Dask parallel computing library in conjunction with the Pangeo framework, under the mentorship of SAIC Scientific Programmers Chris Blanton and Aparna Radhakrishnan. (The Pangeo project is an ecosystem of open-source technologies designed to facilitate scientific analysis of large datasets, on and off the cloud.) Boh's preliminary evaluation of these new data analysis technologies at GFDL gave GFDL's Data Portal team valuable information as they improve their data analysis infrastructure, coping with ever-increasing data volumes.

CIMES Associate Director Sonya Legg also acknowledged the volunteer mentors and hosts who are an integral component to CIMES' efforts to increase

participation in the climate-related sciences. "They are committed to nurturing our diverse community of talented interns and are energized by their collaborations."

In addition to Krasting, Paulot, Blanton, and Radhakrishnan, hosts included Vaishali Naik (GFDL), Larry Horowitz (AOS/GFDL), Liping Zhang (UCAR), Ming Zhao (GFDL) Steve Griffies (AOS/GFDL), and Graeme MacGilchrist (AOS).

Postdocs and graduate students served as secondary mentors to help the interns navigate the Princeton/GFDL culture. Among the lab and social events interns participated in were bi-weekly lunches in the GFDL courtyard organized by OAR/GFDL Administrative Support Specialist Latoyia Kirton, seminars, tutorials, cookouts, an informative Q&A session on graduate school led by CIMES Associate Director Sonya Legg and members of the AOS program faculty, and GFDL's summer picnic.

As a culminating experience, the 2019 Cohort presented the results of their summer research to members of the GFDL/AOS/CIMES community during 20-minute informal presentations.

The 2019 CIMES summer interns included Nana Yaa Takyia Afreh, Nkeh Boh, Ana Bolivar, Alex Chang, Maurizia De Palma, Mariela Arceo Madriz, and Alexandra Matthews.

The program will continue in 2020, building on the success of the previous four years. ■

## **Leo Donner Named 2019 AAAS Fellow**

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

AOS Faculty Member Leo Donner, a GFDL physical scientist, was elected as an AAAS Fellow for advancing understanding of atmospheric convection and its treatment in Earth System Models, and service to the climate science community. He is widely recognized for his novel work on cloud and convective processes in the atmospheric general circulation. His research has yielded important insights about interactions between processes on the scales of clouds and convective systems and large-scale atmospheric flows.

Donner has been with GFDL since 1991, and he has been a lecturer at Princeton University since 1993. His contributions to atmospheric science have been recognized with numerous awards from the Department of Commerce, NASA, and the University of Michigan Alumni Society. He also became a Fellow of the American Meteorological Society in 2019.



*AOS Faculty Member Leo Donner, a GFDL physical scientist*

This year's AAAS Fellows were formally announced in the AAAS News & Notes section of the journal Science on November 29, 2019. New Fellows will be presented with an official certificate and a gold and blue (representing science and engineering, respectively) rosette pin on Saturday, February 15, 2020 at the AAAS Fellows Forum during the Annual Meeting in Seattle, Washington.

AAAS is the world's largest general scientific society and publisher of the journal Science, as well as other scientific journals. AAAS was founded in 1848 and includes more than 250 affiliated societies and academies of science, serving 10 million individuals. The nonprofit AAAS is open to all and fulfills its mission to "advance science and serve society" through initiatives in science policy, international programs, science education, public engagement, and more. ■

## **Jeevanjee Receives 2019 James R. Holton Award**

Nadir Jeevanjee will receive the 2019 James R. Holton Award at the 2019 American Geophysical Union Fall Meeting, to be held December 9-13 in San Francisco, CA. The award is given annually in recognition of outstanding scientific research and accomplishments of early-career atmospheric scientists.

An Associate Research Scholar in AOS and former Hess Fellow in Geosciences, Jeevanjee studies the physics of clouds, radiation, and climate using a hierarchy of approaches ranging from pencil-and-paper theory to comprehensive simulation.



*AOS Associate Research Scholar Nadir Jeevanjee*

As a lead author and with numerous collaborators, Jeevanjee has studied fundamental aspects of the dynamics of convective clouds, the radiative transfer (i.e. greenhouse effect) of H<sub>2</sub>O and CO<sub>2</sub>, and the interplay between radiation and convection.

The award, established in 2004, is named in honor of past AGU Revelle medalist, James R. Holton – an outstanding atmospheric scientist, educator, and mentor.

Jeevanjee is the eighteenth recipient of the Holton award and follows in the footsteps of AOS Alumnus Tapio Schneider \*01 (2004), Arlene Fiore, a former AOS postdoc and GFDL physical scientist (2005), Massimo Bollasina, a former AOS associate research scholar (2013), Karin Van der Wiel, a former AOS Postdoctoral Research Associate (2017), and Ángel F. Adames-Corraliza, formerly GFDL/UCAR (2018). ■

## **Nereus Ocean Science Conference Held at Princeton**

The final Nippon Foundation Nereus Ocean Science Conference was held from September 14-15, 2019 in the Edward C. Taylor Auditorium of Frick Chemistry Laboratory on Main Campus. A group of cross-disciplinary experts presented their research and reflected on the culmination of nearly a decade of interdisciplinary research, with an eye toward the future.



*Taylor Commons (Frick Chemistry Laboratory atrium) (Credit: Princeton University, Office of Communications)*

The Nereus Program is a global partnership of 20 leading institutes working to advance our comprehensive understanding of the global human-ocean system across the natural and social sciences. Launched in 2011, the Program's research spans from oceanography and marine ecology to fisheries economics and impacts on coastal communities.

Nereus Principal Investigator Jorge Sarmiento, the George J. Magee Professor of Geoscience and Geological Engineering, Emeritus, and special guest Mitsuyuki Unno, executive director at The Nippon Foundation delivered welcoming remarks, following an introduction by Andrés Cisneros-Montemayor (University of British Columbia) and Katy Seto (University of Wollongong, Australia).

The meeting featured a series of presentations by Nereus Program research fellows, principal investigators, alumni, research associates and guests, and collaborative panel discussions highlighting the following themes: Changing Ocean Systems; Changing Marine Ecosystems; Changing Fisheries and Seafood Supply; Changing Social Worlds of the Oceans; Ocean Governance Beyond Boundaries; and Opportunities of Changing Ocean Governance for Sustainability. In each session, presenters gave five-minute lightning talks on their research and areas of expertise. The talks corresponded to a chapter (authored by the presenter) in the recently released book *Predicting Future Oceans: Sustainability of Ocean and Human Systems Amidst Global Environmental Change*, a guiding textbook for ocean advocates around the world, and a powerful tool to explain the “scientific evidence” behind the ocean crisis.

Following the presentations, a panel of experts convened to exchange viewpoints on the session's theme, and to reflect on the future direction of marine issues.

Over 50 panelists and presenters covered a multitude of topics from extreme events and marine pollution to high seas governance and seafood supply chain over the course of the event. Among the participants were Sarmiento, GFDL Research Oceanographer Charlie Stock, a Nereus principal investigator, former AOS Associate Research Scholar Ryan Rykaczewski, a

Nereus principal investigator, former AOS Postdoctoral Research Fellow Thomas Froelicher, a Nereus principal investigator, AOS Associate Research Scholar Fernando Gonzalez Taboada, a Nereus fellow, former AOS Postdoctoral Research Associate Kisei Tanaka, a Nereus fellow, and Rebecca Asch, Natasha Henschke, and Kelly Kearny, Nereus alumni.

On the second day and last day of the conference, there was a visit by Yohei Sasakawa, chairman of The Nippon Foundation. He gave a keynote address and participated in a special panel discussion on the future state of the oceans with AOS Alumnus Kelly Kearny (University of Washington) and Phillippe Cury (IRD, Institut de Recherche pour le Développement).



*Panel discussion on the future state of the oceans L to R: Director (Policy) Yoshitaka Ota; Nereus Alumnus & Research Scientist Kelly Kearney (University of Washington); Senior Scientist Philippe Cury (IRD); & Nippon Foundation Chairman Yohei Sasakawa (with translator) (Credit: Nereus Program)*

The conference concluded with a reflection on the cross-disciplinary collaboration and research efforts of the Nereus Program and its participants, and a final presentation by Nereus Director (Policy) Yoshitaka Ota.

As the next step forward, the Nippon Foundation plans to support the “human network” that was cultivated from the Nereus Program, according to Sasakawa, as the Foundation embarks on a new interdisciplinary global network. ■

## **Tsung-Lin Hsieh Bridging Science and Art**

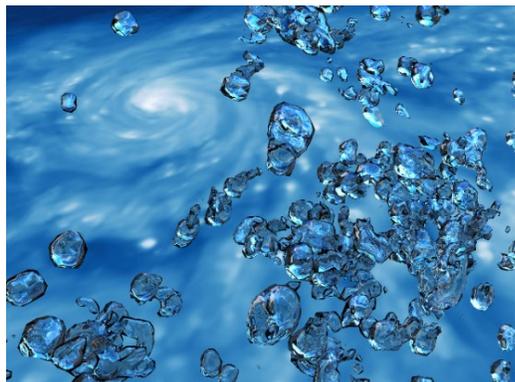
Science and art have come together at the New York Hall of Science from September 10 to January 10, 2020 in “Weather the Weather,” a group exhibition curated by Marnie Benney of the SciArt Initiative that explores the study and experience of weather. AOS Graduate Student Tsung-Lin Hsieh is among the artists whose work is currently on display.



*L to R: AOS Graduate Students Houssam Yassin & Tsung-Lin Hsieh at "Weather the Weather" SciArt Initiative exhibition at the New York Hall of Science (Credit: SciArt Initiative)*

Describing his motivation, Hsieh said, "Our climate models produce beautiful solutions, and with a little more effort to add color and lighting, an image can be made aesthetically pleasing."

Hsieh, who previously won first place in Princeton University's 2017 Art of Science competition, submitted his digital image titled "Raindrops in a Hurricane" in the spring. His submission was among those selected for inclusion in the fall exhibition of weather-inspired art, due to its aesthetic excellence and scientific interest.



*Raindrops in a Hurricane, 2019. Digital Print.*

The exhibition includes over 20 images that highlight the beauty and creativity of scientific imagery. Hsieh's image combines moisture variables from a cloud-resolving model (foreground) and a regional atmospheric model (background) used for his research on clouds and hurricanes.

On November 2, Hsieh participated in the exhibition's mid-show reception, which served as a forum for dialogue surrounding the connectivity of art and science. The event was well attended by artists and supporters of the arts and sciences, including AOS Graduate Students Cindy Wang and Houssam Yassin.

"It was fun to talk to professional artists," Hsieh said. "Many of them make nature-inspired art and are interested in the science. Some seemed surprised by how realistic computer simulated weather looks."

The exhibition will be on view through January 10, 2020. On Saturday, December 7, 2019, SciArt will host a Curator/Artist talk, with Hsieh among the participants. This will be the final public event of the exhibition.

SciArt Initiative is a nonprofit organization dedicated to bridging the gulf between the arts and sciences. Through their biannual art exhibits, monthly public events series, and online portal, they aim to stimulate and cultivate the growth of science-art interactions, connections, and collaborations across disciplines on a global and local scale. ■

## **QUEST Summer Institute Enhances Teachers' Knowledge in Science and Math**

Teacher learning, much like student learning, works when it focuses on the needs of teachers as learners. With this in mind, teachers from surrounding New Jersey school districts gathered as learners on Princeton's Main Campus for the 2019 QUEST summer institute, "Weather and Climate." The weeklong Institute, held July 8-12, 2019, was sponsored by the Cooperative Institute for Modeling the Earth System (CIMES), in partnership with Princeton University's Program in Teacher Preparation.



*QUEST Instructor Steve Carson facilitating Weather & Climate unit*

The professional development program, initiated more than 30 years ago and whose formal name is Questioning Underlies Effective Science Teaching, fosters science literacy in educators through self-directed investigation and hands-on laboratory experiments. Under the guidance of content experts Steve Carson, a Princeton Township middle school teacher and former GFDL researcher, and Danielle Schmitt, manager of the Geosciences undergraduate lab, teachers examined climate system models and identified patterns of typical weather conditions over different scales and variations. Daily experiments relating to the interactions of air, water, and land powered by energy from sunlight furthered the teachers'

understanding of air pressure, temperature, seasons, the greenhouse effect, humidity, clouds, wind, and the Coriolis effect.



*2019 QUEST participants learn by doing.*

The participating teachers also learned about the work of CIMES Researchers Nadir Jeevanjee, an AOS associate research scholar and AOS Faculty Member Laure Resplandy, an assistant professor of geosciences and the Princeton Environmental Institute, who served as guest speakers.

Having the opportunity to engage in discussions with experts in the field “cleared up misconceptions that I had and my students have,” said one of the participating teachers. She found the research environment to be a highly collaborative one, dispelling the myth that scientists work in the lab in isolation.

The ability to explain climate phenomenon relative to students’ everyday experiences, as required by the Next Generation Science Standards, is only one positive outcome of Institute, according to Anne Catena, the director of Professional Development Initiatives, a lecturer, and program associate with Teacher Preparation. She found that a typical sentiment among QUEST participants was that Program should be a requirement to teach science.



*QUEST teacher tackles hands-on laboratory experiment*

In addition to gaining a better understanding of the content in relation to their pedagogical practices, the

teachers learned to articulate questions and pursue answers to those questions, learning from mentors and colleagues alike, and to learn science through investigation and inquiry – a model teachers were encouraged to instill in their own classrooms when school resumed in the fall.

Throughout the week, Carson, who has been leading the QUEST institutes for over 20 years, and Schmitt not only encouraged scientific inquiry and investigation, but also gave teachers the tools they need to go back to their classrooms and feel comfortable trying them out.

In total, 11 teachers, of grades 3-6, from the following districts participated in QUEST’s Weather and Climate institute this past summer: Hillsborough, Montgomery, Princeton, South Brunswick, Trenton, and West Windsor-Plainsboro. Among all participating teachers, approximately 700 students will benefit from what the teachers took away from the experience.

Six Trenton teachers, who work with a growing cohort of historically underserved students, were able to attend the institute at no cost, thanks to the CIMES support, according to Catena.

“This is critical to inform Trenton teachers’ work with underrepresented groups of students, as the urban district does not have funds that enable teachers’ continued learning,” she said.

The QUEST program will continue next year with support from CIMES. ■

## Climate Up Close

A team of climate scientists, among them AOS/CIMES researchers, raises the question, When was the last time you talked to a climate scientist? For many in the general public, the answer is never.



The apolitical and policy-neutral group, Climate Up Close, is committed to change that by making the essentials of climate science accessible to the broadest audience possible. Its team of experts, including AOS Associate Research Scholar Nadir Jeevanjee, Jake Seeley (Harvard University), AOS Graduate Student Aaron Match, and Nathaniel Tarshish, a former AOS research specialist, with the support of Communications Strategist Emma Ignaszewski, travels across the

United States, giving the public an opportunity to meet with them face-to-face.

The discussions are audience-driven and focus on simple but important climate science questions, addressing the state of climate science, climate context, and climate change and its impacts. The climate scientists prepare all of the content and visuals, and facilitate group discussions as well as question and answer sessions, tailoring their presentations so that they are easily understood. In doing so, they hope to bridge the gap between the national conversation, the conversations around the kitchen table, and the conversation scientists are having in their scientific labs and classrooms, according to Tarshish, a graduate student studying the physics of climate at UC Berkeley.

This past summer, the scientists toured Central Pennsylvania, with events in Gettysburg, Harrisburg, Carlisle, Hummelstown, Shippensburg, York, and Lancaster. The Lancaster event at St. John's Episcopal Church was covered on a [local TV newscast](#). It was the seventh in a series of events hosted by the scientists in the Susquehanna Valley.



*Climate Up Close, Lancaster, PA*

“Our motivation was two-fold ... one motivation was a sense that many people on the street are interested to learn more about climate change, if it could be made accessible and especially if it could help them parse the various and sometimes conflicting messaging they receive through the media,” said Jeevanjee. “Another motivation was the sense that climate skepticism springs, in part, from a lack of trust in climate scientists, many of whom are educated at elite universities like Princeton and who may thus seem distant to people living further from academic centers. We thought that face-to-face conversation might help bridge this ‘trust gap’, hence the name Climate Up Close.”

Jeevanjee said that the response to the tour has been positive, and that people seem to have really appreciated the scientists’ presence and their effort to deliver the science accessibly.

Reaching out to the general public has not always been a strong tradition for the scientific community, who may believe that nonscientists are either uninterested in their work or unable to understand it. The Climate Up Close scientists see it differently. Rooted in transparency, opportunity, and inquiry, they believe that people should

see the evidence for themselves, ask questions directly to the scientists, and make their own judgments. For them, this is truly an idea whose time has come.

“Once we go down our scientific rabbit holes and learn things, I personally feel the responsibility to come back up out of the rabbit hole and talk to people and tell them what we found,” Jeevanjee said. “For me personally, that’s why it’s important to do this work and to continue to do this work. Otherwise, as a scientist, I feel I am not fulfilling my obligation to society.”

Climate Up Close is financially independent, with funding for traveling expenses coming from small donations.

To get involved or learn more, visit the Climate Up Close website at: <https://www.climateupclose.org/> ■

## **AOS Annual Retreat ... Community Building at its Best**

With a near record number of graduate students, postdocs and faculty participating, the AOS annual retreat was one of the largest in its eight-year history. Members of the AOS community gathered on the picturesque grounds of Mountain Lakes House, less than two miles from the heart of Princeton yet a world away from daily routines of the lab and classroom, on September 10 for a day of scientific dialogue and social interaction.



*AOS Faculty, postdocs, and students  
underneath the Mountain Lake House canopy*

Since 2012, the AOS retreat has been a fitting way to mark the beginning of the academic year, create community, and forge new friendships. The event also provided an opportunity for the Program to welcome its newest members --AOS Graduate Students Glen Chua, Benjamin Johnson, Oluwatoyosi (Toyo) Sadare, Chenggong Wang, and Cindy Wang.

Following breakfast, participants were broken into groups and introduced to a series of interactive stations, designed to foster cooperation and teamwork. In one

station, organizers gave the groups several sling psychrometers, instruments consisting of two thermometers – one of which has a wet wick around its bulb (wet bulb) and the other that remains dry (dry bulb) – to demonstrate how to estimate relative humidity by using evaporative cooling. By slinging the instrument around in a circular motion (the fun part!), the water evaporates off the wick and removes heat from the thermometer. Evaporative cooling will continue on the wet bulb until the relative humidity of the wick is in equilibrium with the surrounding air. The temperature difference between the two thermometers is converted into a dew point temperature and relative humidity, using a chart.

At another station, groups were given cups of water with varying temperatures and locking syringes. After pulling water into the syringe, team members closed the lock and created a small vacuum chamber, thereby causing the water to boil. “This demonstrated equilibrium vapor pressure and how boiling point is a function of both temperature and pressure,” said AOS Graduate Student Shawn Cheeks, a member of the retreat’s organizational committee.



*Team building at the 2019 AOS Retreat*

A CO<sub>2</sub> experiment at a third station demonstrated the greenhouse effect by having participants look through a tube filled with CO<sub>2</sub> with an infrared (IR) camera. The object appears colder “because the CO<sub>2</sub> absorbs some of the IR radiation, which is how the greenhouse effect works,” said AOS Graduate Student Allison Hogikyan, a co-organizer of the event.

Over lunch, members of the AOS community were free to kick back with friends, both old and new.

“We get to meet the newcomers to the Program, see folks that we may not normally see often, and interact with each other outside of the normal classroom/lab environment,” said Cheeks. “The retreat is a great opportunity for the Program to get together, get outside, and have some fun together.”



*AOS Faculty Members Sonya Legg & Larry Horowitz take an active role in the CO<sub>2</sub> experiment.*

In the afternoon, teams competed in two lively rounds of Mad Libs, using conclusions of two seminal papers – Held & Soden (2006) and Manabe & Wetherald (1967) – which produced an unpredictable wedding of words and laughter. The reimagined word game appeared to be a crowd favorite, according to Cheeks.

The day’s festivities wrapped up with a culminating activity, Absurd Research Proposals – a perfect mix of science and community-building hilarity. Groups were tasked with creating an absurd research proposal to solve some of humanity’s greatest unsolved problems, accompanied by a presentation that would convince colleagues to “fund” their research.

“The monarch butterfly wings drawn on poster paper by AOS Faculty Member Bob Hallberg for AOS Graduate Student Aaron Match to demonstrate how a butterfly would be affected by their group’s proposed experiment,” was a highlight for many, including Hogikyan.

“The retreat is a series of team building activities meant to provide avenues for AOS faculty, students, and postdocs to start talking to one another,” Hogikyan said. “There were so many conversations happening by the end of the day that we skipped the last activity!”

As in past years, an organizational committee comprised of graduate students and faculty members oversaw the planning and implementation of the retreat, including scientific and social activities. Committee members included AOS Graduate Students Shawn Cheeks and Allison Hogikyan, and Faculty Members Stephan Fueglistaler and Steve Garner, who served on the committee every year since the inaugural event in 2012. AOS Graduate and Department Administrator Anna Valerio lent administrative support to the committee members during the planning process.

“I was thrilled that everyone was so engaged, Hogikyan said, “and I think we could have had any activities planned at all and people still would have worked well together and come up with fun ideas.” ■

## AOS & CIMES Research in Action

*[This column is intended to focus on AOS & CIMES research accomplishments and milestones, past, present, and future. In this issue, we highlight the accomplishments of AOS Postdoctoral Research Associate Haidi Chen who spent 4 years in the AOS Program.]*

AOS Postdoctoral Research Associate Haidi Chen will leave Princeton in late December, after four years at Princeton University. Before joining AOS, Haidi earned her Ph.D. in Atmospheric and Oceanic Science from University of Wisconsin, Madison. Her previous work primarily focused on using in situ observations to assess mesoscale and submesoscale dynamics and their impact on biological carbon pump in the oligotrophic gyres. While at Princeton, Haidi worked with Jorge Sarmiento as part of the Southern Ocean Carbon and Climate Observations and Modeling project (SOCCOM).



AOS Postdoctoral Research Associate  
Haidi Chen

The Southern Ocean is the region of the global ocean where deep and bottom waters ascent to the surface and interact with the atmosphere. It exerts a prominent influence on the global heat and carbon balance. However, the Southern Ocean's remoteness and hostile environment make ship-based observations scarce and summer-biased. Recent advances in year-round biogeochemical measurements from profiling floats and eddy-resolving climate models have enabled oceanographers to start to understand the underlying processes regulating the Southern Ocean heat and carbon uptake and its variability at various spatial and temporal scales.

Using hydrographic observations, Haidi showed that excess heat and carbon storage in response to rising atmosphere CO<sub>2</sub> are distinctly different in the Southern Ocean. It challenges the conventional view that both of them are primarily driven by surface uptake and passive

subduction into the thermocline without circulation change. Haidi analyzed the GFDL eddy-resolving climate model CM2.6 — which successfully reconstructed the observed storage patterns—and identified (1) the control to the excess heat and carbon storage in the Southern Ocean, and (2) where their storage difference arises from. The results show that the differences arise primarily from a decadal time-scale change of the residual-mean overturning circulation that redistributes the preindustrial heat and carbon. This work was published in *Geophysical Research Letters* in January 2019, and provides the basis for an appraisal of the sensitivity of Southern Ocean heat and carbon to circulation changes with varying wind and buoyancy forcing.

The modern Southern Ocean high-latitude is a net source of old, pre-industrial carbon dioxide to the atmosphere. The balance between this natural CO<sub>2</sub> release near Antarctica and its uptake by the global ocean controls the natural variations in the atmospheric CO<sub>2</sub> concentration. Using SOCCOM floats and shipboard observations, Haidi developed a mechanistic understanding of the Southern Ocean natural CO<sub>2</sub> outgassing in relationship to deepwater ventilation and upwelling pathway. She found that that the major band of Southern Ocean CO<sub>2</sub> release arises through the ventilation of upper and lighter deep waters originated from the deep northern Pacific and Indian oceans. While these waters have a lower carbon content than heavier deep waters, their potential to release CO<sub>2</sub> to the atmosphere is the highest. In turn, outgassing from the high-carbon lower deep and bottom waters is hindered by their carbon chemistry, which has important implications for their ability to store carbon in the deep ocean on long time scales.

After returning to Hong Kong and completing this work, Haidi plans to pursue opportunities in industry. ■

## AOS & CIMES News



### Applications now open for 2020 CIMES Summer Internships!

The Cooperative Institute for Modeling the Earth System (CIMES) is recruiting both undergraduate and graduate students for 8-10 week research internships in atmospheric, oceanic and earth system science. Awardees will work with host scientists at the NOAA/GFDL, a world-leading center of earth system modeling, research and prediction.



Students whose participation will add to the diversity of researchers in earth system science, including students from underrepresented groups, and first generation college students, are particularly encouraged to apply!

**Deadline: January 15, 2020**

<https://cimes.princeton.edu/education-outreach/intern-program>

\*\*\*\*\*

Congratulations to **Xin Rong Chua** who successfully defended her Ph.D. Thesis, “The Effects of Greenhouse Gases and Absorbing Aerosols on Tropical Precipitation” on August 5, 2019.

\*\*\*\*\*

Congratulations to **Justin Ng** who successfully defended his Ph.D. Thesis, “On the Seasonal Predictability of East Asian Rainfall and Rapidly Intensifying North Atlantic Tropical Cyclones” on August 9, 2019.

\*\*\*\*\*

Congratulations to **Spencer Clark** who successfully defended his Ph.D. Thesis, “Controls on Tropical Mean State and Intraseasonal Precipitation Variability in an Idealized Moist Atmospheric Model” on August 12, 2019.

\*\*\*\*\*

Congratulations to **Jenny Chang** who successfully defended her Ph.D. Thesis, “Eddy Equilibration in Idealized Models of the Extratropical Troposphere” on August 15, 2019.

\*\*\*\*\*

[Structure and Performance of GFDL’s CM4.0 Climate Model](#)

A new [paper](#) led by a team of GFDL and Princeton researchers, among them AOS and CIMES scientists, describes GFDL’s latest multi-purpose atmosphere-ocean coupled climate model, CM4.0. It consists of

GFDL’s newest atmosphere and land models at about 100 km horizontal resolution, and ocean and sea ice models at roughly 25 km horizontal resolution. A handful of standard experiments have been conducted with CM4.0 for participation in the Coupled Model Inter-comparison Project Phase 6 (CMIP6), an archive of climate model results utilized by the Intergovernmental Panel on Climate Change (IPCC) and the climate research community more generally. The paper was published recently in the *Journal of Advances in Modeling Earth Systems (JAMES)*.

[GFDL Research Highlight](#)

\*\*\*\*\*

[On the Mechanisms of the Active 2018 Tropical Cyclone Season in the North Pacific](#)

The 2018 tropical cyclone (TC) season in the North Pacific was very active, with 39 tropical storms including eight typhoons/hurricanes. Unlike the typical limitations in skill of seasonal predictions made before April initial forecasts, the active 2018 TC season was successfully predicted by the Geophysical Fluid Dynamic Laboratory Forecast-oriented Low Ocean Resolution (FLOR) global coupled model 3–5 months in advance (i.e., successful predictions from 1 February 2018).

The authors of a [paper](#), recently published in *Geophysical Research Letters* and led by **Yitian Qian**, an AOS visiting student research collaborator, used a suite of idealized experiments with three dynamical global models to show that the active 2018 TC season was primarily caused by warming in the subtropical Pacific associated with the positive phase of the Pacific Meridional Mode, and secondarily by warming in the tropical Pacific associated with Central Pacific El Niño. Former AOS Associate Research Scholar **Hiroyuki Murakami** (UCAR), AOS Faculty Member **Tom Delworth**, Former AOS Postdoc **Sarah Kapnick** '04 (GFDL), and GFDL **V. Ramaswamy** are among the paper’s co-authors.

[GFDL Research Highlight](#)

\*\*\*\*\*

[Why are Big Storms Bringing So Much More Rain? Warming, Yes, but also Winds](#)

For three hurricane seasons in a row, storms with record-breaking rainfall have caused catastrophic flooding in the southern United States: Harvey in 2017, Florence in 2018 and Imelda in 2019. A new analysis by Princeton researchers explains why this trend is likely to continue with global warming. Both the higher moisture content of warmer air and storms’ increasing wind speeds conspire to produce wetter storms, the researchers reported in a study published recently in the

*Nature* Partner Journal *Climate and Atmospheric Science*. The authors include Maofeng Liu (CEE), CIMES Director **Gabe Vecchi**, professor of geosciences and the Princeton Environmental Institute, James Smith (CEE), and GFDL Research Meteorologist **Tom Knutson**.

[Read more](#)

\*\*\*\*\*

## The GFDL Hot Air Society

**The GFDL Hot Air Society meets every 3rd Monday of the month from 3–4 pm in the Smagorinsky Room.**

The club is an offshoot (not an official association) of Toastmasters International, a non-profit educational organization that operates clubs worldwide to help members improve their communication, public speaking, and leadership skills.

The GFDL Hot Air Society is a no-pressure, supportive and fun environment for improving presentation and communication skills for everyone, both native and non-native English speakers. Colleagues at GFDL and Sayre Hall are welcome to participate.

Sign up for the club mailing list ([oar.gfdl.toastmasters](mailto:oar.gfdl.toastmasters)) to receive meeting announcements or contact Fanrong Zeng for further information.

\*\*\*\*\*

## Arrivals

The AOS Program extends a warm welcome to its newest members – Graduate Students **Glen Chua**, advised by Larry Horowitz; **Benjamin Johnson**, advised by Tom Delworth; **Oluwatoyosi (Toyo) Sadare**, advised by Sonya Legg; **Chenggong Wang**, advised by Gabe Vecchi; and **Cindy Wang**, advised by Leo Donner.

**Matthew Wozniak** arrived in early September, from the University of Michigan, to work with Elena Shevliakova as a postdoc.

**Hemant Khatri** arrived in mid-October, from Imperial College, to work with Steve Griffies as a postdoc.

**Carolin Loscher** arrived in early November, from the University of Southern Denmark, to work as a visiting research scholar with John Dunne and Bess Ward.

**Yan Yu** arrived in early November, from the University of California, Los Angeles, to work with Paul Ginoux as a postdoc.

**Benjamin Taylor '19** (Department of Physics) will be working as a research specialist with the Sarmiento Group effective December.

## Departures

AOS Associate **Levi Silvers** accepted a research scientist position at Stony Brook University in the Climate Extremes Modeling Group, School of Marine and Atmospheric Science. He ended his AOS appointment on September 1.

AOS Associate Research Scholar **Salvatore Pascale** accepted a research faculty position at Stanford University. He left the Program in early October.

AOS Postdoctoral Research Associate **Li (Alex) Zhang** left the Program in early November, at the end of his appointment.

AOS Associate Research Scholar **Nathaniel Johnson** began his GFDL affiliation (meteorologist) at the end of November.

AOS Postdoctoral Research Associate **Hoi Ga 'Veronica' Chan** will be leaving the Program in early December, at the end of her appointment.

AOS Postdoctoral Research Associate **Haidi Chen** will be leaving the Program in late December, at the end of her appointment.

AOS Associate Research Scholar **Maximilien Bolot** will be leaving the Program in late December, at the end of his appointment.



**We want to hear from you.  
Send your news to:**

**[jcurcio@princeton.edu](mailto:jcurcio@princeton.edu)**

**AOS Program  
Princeton University  
300 Forrestal Road, Sayre Hall  
Princeton, NJ 08540**

**Phone:  
(609) 258-6047**

**Visit our website:  
<<https://aos.princeton.edu/>>**

**Editor: Joanne Curcio  
Email: [jcurcio@princeton.edu](mailto:jcurcio@princeton.edu)**