AOS & CIMES Newsletter

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

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AOS Alums Jane Baldwin, Jaya Khanna, and Rob Nazarian in Conversation

Jane Baldwin

Jaya Khanna

Rob Nazarian

We recently caught up with AOS Alumni Jane Baldwin, assistant professor of earth system science, University of California, Irvine, Jaya Khanna, assistant professor in the School of Earth & Planetary Sciences, National Institute of Science Education and Research (NISER), India, and Rob Nazarian, assistant professor of physics, Fairfield University, to chat about their paths from AOS graduate students to faculty members. Jane graduated in 2018 with a thesis titled "Orographic Controls on Asian Hydroclimate, and an Examination of Heat Wave Temporal." She was advised by AOS Faculty Member Gabe Vecchi. Jaya graduated in 2016 with a thesis titled "Regional Hydro-Climatic Impacts of Contemporary Amazonian Deforestation." She was advised by David Medvigy. Rob graduated in 2017 with a thesis title "Internal Wave Scattering in Continental Slope Canyons." He was advised by AOS Faculty Member Sonya Legg.

My approach to mentorship, research, and teaching was shaped by my time at Princeton.

— Rob Nazarian

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Professor Curtis Deutsch Joins AOS

Curtis Deutsch, a professor of geosciences and the High Meadows Environmental Institute (HMEI), joined the AOS faculty in February.

Deutsch, whose research is aimed at understanding the interactions between climate and ecosystems, models the interactions between biogeochemical cycles and the climate system so that scientists may better understand past environmental changes and predict those in the future.

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Welcome!

The spring term is off and running with many of us back on campus and meeting in person. We know that the semester will not be without challenges, but we are optimistic about what lies ahead, including the warmer weather! Our community has found countless ways to rise above the challenges of the past two years, and we are immensely thankful to all of you.

In this issue, we catch up with AOS Alums Jane Baldwin, Jaya Khanna, and Rob Nazarian and welcome Curtis Deutsch to our faculty. We share news of CIMES Task III awards and feature a project led by Elie Bou-Zeid, an AOS associated faculty member. We highlight CIMES Assoc. Director Sonya Legg's involvement in an effort to support AAPI students in Geosciences as well as our Program's ongoing DEI initiatives and outreach. We welcome all of our AOS/CIMES newcomers!

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

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Can you briefly describe your current research focus? How has it evolved since you left the AOS Program?

Baldwin: My (new and growing!) research group focuses on three main areas: 1) the influence of mountains on climate, especially patterns of rainfall, 2) tropical cyclone risk, and 3) heat waves, their projected changes, and their health impacts. All three directions have roots in my PhD work. However, they have developed in ways I couldn't have anticipated when I graduated! For example, I spent much of my postdoc at Columbia collaborating with the World Bank to develop a tropical cyclone risk model that can estimate economic losses from these extreme events (we've piloted this model for the Philippines but plan to extend it to other regions). This plus my heat waves work has put me more and more in the position of thinking at the intersection of climate dynamics and climate impacts, which is an intellectual space I really enjoy inhabiting.

Khanna: I am currently focusing on two research directions. In the first series of projects, I am in a way expanding my expertise in the research I carried out at AOS. However, I am working with a completely new biome (the Himalayas) as compared to my focus during my PhD (the Amazon). The more novel feature about this venture is that I am, firsthand, setting up a field observational facility in the Himalayas, which is a completely new direction that I have taken as compared to my PhD research. I am also expanding to study climate change signals apart from studying vegetation-climate coupling in this biome. I have fortunately received federal funding to carry out these projects and am collaborating with field hydrologists and ecologists to set up the observatory. The second of the research directions I am taking currently is in the field of climate dynamics over the subtropics. I am specifically studying heat stress and its relationship with atmospheric water vapor under climate change. This is a new research direction for me because so far, I have focused only on vegetation-atmospheric coupling. However, I am truly enjoying working on this problem of climate dynamics with my students and am thrilled with the type of research.

Nazarian: My research focus has broadened significantly since leaving AOS. Since I am at a smaller university, I am the only geoscientist on the faculty, so I wear all of the atmosphere/ocean/climate hats. While I maintain active research projects in small-scale ocean dynamics, I have expanded into problems in atmospheric and climate dynamics which have been exciting to explore (and all the more fun since I've been able to collaborate with other AOS alums). I've also been publishing in the area of geoscience education and conducting interdisciplinary studies in climate economics with my colleagues in the Fairfield University Dolan School of Business. While these projects are wide-ranging, they all leverage the scientific skills I learned during my time in the AOS Program.

As a graduate student, did you always have a clear idea of your intended career trajectory or did your career path develop more organically?

Baldwin: I definitely did not always have a clear idea of my intended career trajectory. I was potentially interested in being a professor. However, I considered a number of other directions throughout my PhD. I did a PEI-STEP fellowship with Princeton's policy school partially to explore government-oriented career paths. I did an internship one summer at a start-up that specializes in analysis of remote sensing data called Descartes Labs. I did a bunch of informational interviews to better understand the range of career paths I could pursue with a PhD. There's a lot of exciting options out there! Ultimately, however, I decided I really like that academia values being curious and inquiry for the sake of understanding, and so I started applying for faculty positions. I'm really grateful to have ended up where I am at UC Irvine—I love the research I can do here, the people in my department, and sunny SoCal weather. However, I think career trajectories are somewhat chaotic, and I was perhaps just one Lorenz butterfly away from ending up somewhere else!

Khanna: As a graduate student, I had a very clear idea of my career trajectory and I have, more-or-less, ended up following that trajectory. However, I should point out that I had clarity because I had spent several years experimenting with slightly other trajectories before joining Princeton. So, I had very specific plans when I entered the PhD program at AOS.

Nazarian: Before I began my studies at Princeton, I knew that I wanted to be at a primarily undergraduate institution after completing my PhD. These institutions differ from traditional RIs, since faculty are expected to place equal weight on teaching and research, as well as to conduct their research with undergraduates. I am appreciative of the opportunities and resources available through Princeton and GFDL to best position myself for such a career, and would encourage current students to leverage the resources available through the University if

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they are considering a similar career path.

What are some habits you developed as an AOS graduate student that helped you prepare for a faculty position?

Baldwin: This is not so much a "habit," but in AOS I was privileged to be surrounded by world-class atmospheric scientists, oceanographers, numerical modelers, etc. Learning from all these outstanding individuals what constitutes high-quality, impactful research, and the perseverance it takes to conduct such research, was probably the most important preparation I could get for a faculty position.

In a totally different direction, I learned the hard way during my PhD that research is a marathon not a sprint, and it is necessary to engage in healthy self-care to remain productive. What that self-care looks like varies for everyone, but it's worth experimenting with during one's PhD when you have time and the flexibility! For me it meant getting a decent amount of sleep, exercising pretty regularly (loved classes at Gratitude Yoga during my PhD!), and making time to hang out with friends with diverse goals and interests. Obligations only increase in a faculty position, and having some sense of your limits and what is restorative for you is really helpful to prevent burnout.

Khanna: Reflecting upon the method of scientific inquiry, reading current research and staying updated about the most important research questions in the field, presentation and writing skills, effective teaching, and presenting one's point concisely.

Nazarian: One of the key habits from my time in the AOS Program that I use as a faculty member is writing a list of work that I need to do for the day, week, and month. It's probably overkill, but it keeps me mindful of upcoming deadlines and helps me to objectively prioritize the research, teaching, and service commitments on my plate. It also helps to keep me balanced so that I am not spending too much time in any one of those three areas, since all three are required for tenure and faculty advancement.

How did you prepare for academic interviews? In hindsight, is there anything you wished you had known before your interviews?

Baldwin: The most practical advice I got is if you want a faculty position, you should "apply early and often." When I first started applying, I did not yet feel ready. However, applying and writing research, teaching, and diversity statements helped me envision what I wanted to do as a faculty member, and that I could do it. Additionally, interviewing well is a skill, so it took me a couple of interviews before my faculty pitch was really dialed in. So again, apply early and often if you want to be a faculty member—worst case you get some really helpful practice and best case you get a job!

Earlier in my PhD, meeting with researchers who came to visit was helpful in expanding my network and getting practice in the kinds of discussions one has during faculty interviews. It helped me learn how to describe my work clearly and confidently to others, and engage enthusiastically with other's research.

Finally, I wished I had known how much "fit" matters for academic positions. When you're applying for faculty positions, you almost inevitably get rejected from some. It's important to not take these rejections to heart too much—often they just wanted someone with a slightly different research/teaching focus, and it had nothing to do with the quality of your work. Of course, there are things one can do to increase the odds of success—publish, become good at giving seminars, demonstrate ability to get external funding of some kind, have some teaching experience. But there's a large element that depends on what hole in expertise the department you're applying to wants to fill, and you shouldn't take that personally.

Khanna: I prepared for all my academic interviews with my husband, who was also a graduate student at Princeton. He has similar training and outlook towards science presentation as I do because we were trained at the same institute at the same time. His feedback was sufficient for me to prepare for interviews at the institutes I was targeting. I think it is important to know something about your 'audience' or your 'interviewers' before you enter the interview. That is, the interview panel may have a certain set of expectations, which you may display to have if you can guess the expectations beforehand. These are expectations over and above those related with your expertise. For example, at one of my interviews the panel probably wanted to know about my interests in consultancy projects, which I had not expected before the interview. This 'preparation' I lacked initially because of which I could not succeed in the first couple of interviews.

Nazarian: The majority of my time applying to faculty positions and preparing for interviews was spent learning as much as I could about each institution and

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using that to write a cover letter to each school. In my experience on search committees since then, I've seen firsthand how a customized cover letter can elevate an applicant and give them a strong chance at making the shortlist. It also helped me to articulate how I could contribute to the programs to which I was applying. While writing individual cover letters is time-consuming, I think the time is well spent, since the research on the institution can be also used during the preliminary and finalist interviews.

How did your experiences as an AOS graduate student shape and guide how you now mentor students, and how did those experiences factor into your approach to teaching and research?

Baldwin: As a first-year professor, my mentoring style is still very much in development. However, being in AOS and in particular part of my PhD adviser Gabe Vecchi's group, definitely helped inspire the group vibe I want to cultivate. I benefited profoundly from Gabe mixing direct scientific critique and feedback with infectious enthusiasm and encouragement. I strive to pay some of that positive encouragement Gabe gave me forward to my own graduate students, with the hope it will help buoy them up through those hard and lonely parts of a PhD. Additionally, I was grateful for Gabe's willingness to talk about ideas not always strictly related to the project at hand—this was vital in developing my scientific creativity and confidence in my own ideas. I encourage the students I work with to bring in information that excites them and share it, even if it seems tangentially related. Game-changing ideas can come from very unexpected places!

Khanna: My experiences at AOS have been the biggest influence on my approach towards mentoring, teaching and research. Two most important lessons from my time at AOS and Princeton that guide me as a mentor, teacher and researcher are – teaching in no way should be limited to a textbook and that usually there is scope of improvement or novelty in research that has already been published. As such, I encourage the students in my classes, my mentees or research scholars to be bold while implementing their research ideas and trusting their intuition.

Nazarian: My approach to mentorship, research, and teaching was shaped by my time at Princeton. For all three of these responsibilities, the importance of individualized attention is at the forefront, based on my experiences and close faculty-student work in the AOS Program. Whether it's in research meetings or office hours, it's important to lead with empathy and patience.

What insights would you share with those who are considering academic careers, particularly as faculty?

Baldwin: It's a fantastic career path, but it's also not the only fantastic career path after a PhD. For example, there are increasingly exciting private sector and government options in the climate risk space. Consider your options, so that if you decide to pursue a faculty position you can feel really confident and excited about your choice!

Khanna: An academic position is more stressful than other similarly paying careers in the sense that we are paid to keep thinking and producing novel insights of the physical world. This I find is easier said than done. This expectation from an academic position necessarily entails anxiety and stress. So at least in my case I could strike the balance by thinking about what kind of an academic position I wanted for my life and in what types of institutes. The nature of research inherently is such that it does not depend much on what type of institute you are employed at as long as it is a good academic institution, so finding a 'compromise' solution is not necessarily harmful to your career. Hence, choosing your target institutes wisely may pay off in the end in the sense that you will be more likely to get a suitable job more quickly.

Nazarian: My advice to those considering a career in academia is that, while the application process can be daunting, don't let that deter you. If you want to pursue a career in academia, go for it. In the process, feel free to lean on your academic network; there are so many AOS/GFDL colleagues who are happy to offer advice, career mentorship, or letters of recommendation. On the other hand, if you don't want to go into academia, don't feel like that's the only option with your PhD. There are so many fulfilling careers outside of academia too.

Any tidbits of advice on maintaining a healthy work-life balance?

Baldwin: I'm still figuring this one out! Maybe one small thing is to not worry too much if sometimes things are out of balance. Last summer I was planning my wedding and felt I had too much life to deal with and not enough time for work. Now that I'm in my first quarter teaching of my faculty position while spinning up my research group, it feels like I have way too much work. Have some confidence that these things ebb and flow.

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Khanna: Two tidbits – (1) health is wealth and this is not an overstatement. It is extremely easy to compromise your mental and physical health in academia. However, I now feel that any compromise with one's career can't be more important than compromising one's long term health. Like most people in academia, I have learned this the hard way. (2) Planning a family at a 'young' age may be helpful for your overall (mental and physical) health and may help you be relatively more successful in academia.

Nazarian: The best piece of advice that was given to me was to rigidly guard my personal time. For me, that means not checking my email obsessively outside of working hours (that's still a work in progress) and learning how and when to say "no" to new commitments.

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Much of his work focuses on biogeochemical cycles in the ocean, with a particular emphasis on the mechanisms that regulate the cycles of nutrients and oxygen over a range of time scales from years to millennia. He is also working to advance our understanding of the implications of climate change on terrestrial biodiversity.

Deutsch earned his Ph.D. from the AOS Program in 2003, under the mentorship of his thesis adviser Jorge Sarmiento, now Princeton's George J. Magee Professor of Geoscience and Geological Engineering, Emeritus.

He comes to Princeton from the University of Washington, where he has served as an associate professor in oceanography since 2013 and an adjunct associate professor in biology since 2015. He previously was on the faculty of the University of California-Los Angeles from 2007-13.

Deutsch is currently teaching AOS 578 Chemical Oceanography.

"We are delighted to welcome Curtis back to the AOS Program," said AOS Director Stephan Fueglistaler. "His arrival will invigorate research here in a field where AOS has a long-standing tradition of excellence."

Combining numerical models of varying complexity with diverse types of biological and physical data, Deutsch endeavors to discover the ways in which climate produces spatial pattern and temporal variability in ecosystems, and thus how it influences their basic ecosystem functioning.

Professor Curtis Deutsch

He also has been active in efforts to understand the oceanic nitrogen cycle's current and past influence on climate change through its role in containing carbon dioxide in the deep ocean. Deutsch has collaborated with terrestrial ecologists on research to construct simple models for gauging how climate change could affect the fitness and long-term survival of animal species across latitudes.

"He is a global leader and I look forward to his future contributions to research and teaching on the ocean and its chemistry," said Gabriel Vecchi, director of the High Meadows Environmental Institute (HMEI) and deputy director of CIMES.

Among his numerous awards, Deutsch is the recipient of a 2013 Investigator Award from the Gordon and Betty Moore Foundation. He was named a Kavli Frontiers of Science Fellow by the National Academy of Sciences in 2010.

Deutsch is a member of the review board of the Annual Reviews of Marine Science. He holds a B.S. in physics from Oberlin College.

CIMES Awards $515,000 in Earth System Sciences

The Cooperative Institute for Modeling the Earth System (CIMES) has announced awards totaling $515,000 to support seven innovative, cross-disciplinary projects aimed at modeling and understanding the Earth system, projects that align closely with the strategic goals of NOAA's Geophysical Fluid Dynamics Laboratory (GFDL). The projects run from 2022 to 2023 and foster research, teaching, and mentorship in Earth system science.

The recently funded projects include:

Coastal Microscale Dynamics and their Parametrization

Land-Sea breezes are strong air circulations that dominate the wind patterns in coastal zones. They are fueled by the surface temperature differences between the adjacent water and land surfaces. Much remains to be learned about the physics of these circulations, and more importantly about how to represent them in weather and climate models. This is increasingly urgent given the hazards coastal zones are going to face with a changing climate and the potential drastic increase in offshore wind farms. Led by Elie Bou-Zeid, professor of civil and environmental engineering, this project will bridge the gap in physical understanding, apply it to improve forecasting in coastal zones at weather to climate scales, with positive impact for coastal resilience and sustainability.

A Sea-State Dependent Sea Spray Source Function

Luc Deike, assistant professor of mechanical and aerospace engineering and the High Meadows Environmental Institute, will lead research aimed at developing accurate models of sea spray generation function that can be implemented in ocean, atmosphere and Earth system models, with potential impacts on chemical cycles and aerosol production. Deike and collaborators Brandon Reichl, a GFDL research oceanographer, and AOS Faculty Member Steve Griffies, a GFDL physical scientist, are developing and testing a theoretical framework that explicitly accounts for the role of sea spray aerosol generation by wave breaking and bubble bursting, resolving the very large range of scales involved in the process by a sequence of models, from the atmospheric and wave scales (scales of tens to hundreds of km), to wave breaking, (scales of tens of meters), to air bubble entrainment and bubble bursting at the free surface (scales of microns to mm). Once the sea spray generation function is available at global scales through global wave simulations, the researchers expect to collaborate closely with Paul Ginoux, Larry Horowitz and Fabien Paulot at GFDL.

Development and Parameterization of a Trait-Based Model of Zooplankton Diversity for Marine Food Web and Climate Feedback Studies

Tiny marine animals only a millimeter to centimeter in size exert an enormous influence on ocean's food webs and are a primary conduit for the transfer of carbon from the atmosphere to the deep ocean. These so-called zooplankton are also incredibly diverse in their form, sizes, rates of feeding, and tolerance for temperature and oxygen levels. How is this diversity related to the variation in these ocean conditions? How might that diversity change as the oceans get warmer and less oxygen-rich? Answering these questions will require new types of models that represent a wide array of zooplankton species and the traits that describe their distinct physiological responses to environmental conditions. Led by Curtis Deutsch, professor of geosciences and the High Meadows Environmental Institute, in collaboration with GFDL Research Oceanographer Charles Stock and Justin Penn, a postdoctoral research associate in geosciences, this project will take a new approach toward constructing such models, so that the researchers can better understand how zooplankton traits sustain their species diversity, how that diversity will be impacted by a rapidly changing ocean, and how those biological changes may in turn impact the ocean at a global scale.

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GFDL Model Investigation of the Role of the Southern Ocean in the Glacial Cycles

PIs: Daniel Sigman, GEO; Curtis Deutsch, HMEI, GEO; Laure Resplandy, HMEI, GEO

The cold climate of Earth's ice ages was partly due to a low concentration of CO_2 in the ice age atmosphere, leading to a weaker greenhouse effect during the ice ages. In the 1980s, AOS and GFDL scientists first hypothesized that the lower CO_2 concentration of the ice age atmosphere was due to the Southern Ocean, the expansive ocean region surrounding Antarctica. Princeton geoscientists Daniel Sigman, Curtis Deutsch, and Laure Resplandy will collaborate with GFDL scientists to pursue this hypothesis through comparison of GFDL climate model simulations with paleoceanographic data from the Southern Ocean, including data generated in Sigman's lab. The findings may have implications for whether and how the ocean's ongoing uptake of anthropogenic CO_2 and global warming heat will change as climate continues to warm.

Global Warming Simulations at Convection-Resolving Resolution Globally

The advent of global storm-resolving atmospheric model simulations allows scientists to study important processes in the climate system - from storms, coupling between large-scale tropical waves and convection, to processes that may affect climate sensitivity such as convective aggregation - at a scale where convection is explicitly resolved. Such simulations are still numerically very expensive and not widely accessible to researchers yet. A team of interdisciplinary researchers, led by Stephan Fueglistaler, professor of geosciences, will use the GFDL X-SHiELD model to run a small number of year-long integrations (thus covering the full annual cycle) at present day climatic conditions, and in a simple global warming configuration with uniformly increased sea surface temperature. These runs will be complemented with simulations at reduced horizontal resolution to study on the one hand the differences due to resolution, and on the other hand bracket uncertainty due to internal variability. The simulations will be made available to the CIMES community and may serve as a baseline for further specific experiments.

PI: Stephan Fueglistaler, GEO; Co-Investigators: Gabriel Vecchi, GEO, HMEI; Michael Oppenheimer, GEO, HMEI, School of Public and International Affairs; Jessica Metcalf, EEB, School of Public and International Affairs; Bryan Grenfell, EEB, School of Public and International Affairs; Lucas Harris, GFDL

Extreme Rainfall and Flooding

One of the most consequential issues concerning climate change impacts on flooding in the US is whether extreme floods are increasing in frequency. In this project, James Smith, the William and Edna Macaleer Professor of Engineering and Applied Science, and Yibing Su, a graduate student in civil and environmental engineering, will address the following questions: How is rainfall organized in space and time for extreme flood events in the Lower Mississippi River? What are the principal climate drivers of extreme rainfall in the Lower Mississippi River? Can state-of-the-art Earth System Models accurately represent rainfall variability at time and space scales associated with major flood episodes? In addition to flooding in the Lower Mississippi River, analyses will assess rainfall and flood extremes from the remnants of Hurricane Ida in the Northeastern US.

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Urbanization and Compound Heat Waves

A Compound Heat wave is defined as a period of multiple extreme heat days separated by short breaks of cooler days. Prolonged exposure to extreme heat can worsen existing health conditions such as cardiovascular and respiratory diseases, and increase the mortality rate. Also, extreme heat can intensify droughts, cause forest fires and lead to a surge in energy demand for cooling. With global warming, the frequency and intensity of compound heat waves is expected to increase[1], exacerbating these pre-existing risks. In addition to global warming, urbanization can cause local warming often referred to as the 'Urban Heat island effect' where urban areas tend to be warmer than their surrounding rural areas. In this project, a team of researchers in Princeton's Department of Geosciences, High Meadows Environmental Institute and School of International and Public Affairs, NOAA/GFDL, the University of California, Irvine, and Boston University, will assess the effect of urban versus rural characteristics on the intensity and frequency of compound heatwaves, and how the projected increase in compound heat waves can pose different risks for urban vs. rural areas using global climate model simulations of GFDL LM4 with the urban module enabled[2].

Team Members:
Gabriel Vecchi, Princeton Department of Geosciences and High Meadows Environmental Institute; Wenchang Yang, Princeton Department of Geosciences; Michael Oppenheimer, Princeton Department of Geosciences, High Meadows Environmental Institute and School of International and Public Affairs; Elena Shevliakova, NOAA/GFDL; Sergey Malyshev, NOAA/GFDL; Jane Baldwin, University of California, Irvine; Dan Li, Boston University

References:
1. Baldwin, J.W., Dessy, J.B., Vecchi, G.A., Oppenheimer, M., 2019. Temporally compound heat wave events and global warming: an emerging hazard. Earth's Future 7, 411–427. https://doi.org/10.1029/2018EF000989
2. Li, D., S. Malyshev, and E. Shevliakova. "Exploring Historical and Future Urban Climate in the Earth System Modeling Framework: 1. Model Development and Evaluation." Journal of Advances in Modeling Earth Systems 8, no. 2 (June 1, 2016): 917–35. https://doi.org/10.1002/2015MS000578.

CIMES Award Highlight

Coastal Microscale Dynamics and their Parametrization

Walking on the seashore on a hot summer day, you will almost certainly experience a cool breeze blowing from sea to land. Regardless of what the larger wind patterns in the atmosphere are like, this sea breeze tends to persist, driven and sustained by the strong temperature contrast between the land and ocean surfaces. During the day, the hot land surface warms up the overlying air, which then lifts due to buoyancy. This creates low pressure above the land (kind of a "vacuum") that the colder and heavier air over the sea surface rushes in to fill. These two drivers then form a somewhat closed loop of air circulation. At night, the temperature contrast switches and so does the direction of the circulations, resulting in a breeze from land to sea. These patterns make for some nice pictures of plumes moving in opposite directions (Fig. 1) and cool down beach goers, but they also have much more consequential impacts on geophysical systems and human activities.

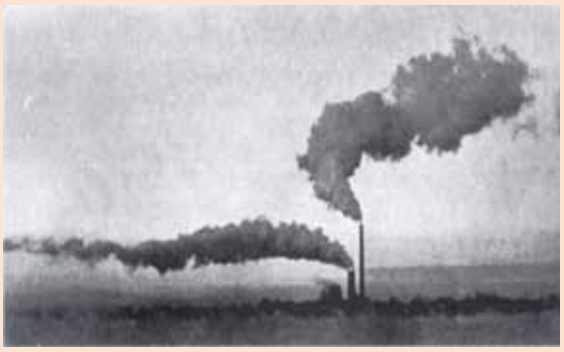

Fig. 1: One of the most famous illustrations of the land-sea breeze circulation (Photo by Ralph Turcotte of the Beverly Times, featured in John E. Simpson Book "Sea Breeze and Local Wind", Cambridge University Press) showing the condensation fog plume from the lower (~ 75 m) chimney moving towards the land (surface level direction of the circulation), while the one from the higher chimney (~ 150 m) moves toward the sea (upper level return breeze of the circulation).

Land-sea breezes heavily influence air quality and thermal comfort in coastal cities (where they are further complicated by urban-rural temperature differences), modify the power potential for near and offshore wind farms, modulate cloud formation, modify coastal circulations in the oceans (upwelling and downwelling) and ultimately impact the large dynamics of the oceans and atmosphere at continental to global scales. This is why a better characterization of the full range of circulation regimes, and under what conditions each occur, is critical for geophysical systems understanding and modeling.

With funding from CIMES, Elie Bou-Zeid, professor of civil and environmental engineering at Princeton, is aiming to use state of the art turbulence resolving simulations to understand why sea breezes are so persistent, how the larger scale atmospheric dynamics modulate the thermal circulation, and under what conditions might these larger dynamics completely destroy the circulations. The challenges of the problem are the large range of parameters that can impact the wind patterns: temperature contrast, roughness contrast, larger-scale (synoptic) pressure gradient magnitude and direction, coast shape, and the memory or inertia of these circulations as the conditions change over the course of a diurnal cycle, to name the main ones.

Previous literature has overwhelmingly focused on the temperature contrast under steady conditions, but the simulations that Mohammad Allouche - a Ph.D. candidate in Bou-Zeid's lab - is conducting are elucidating the strong influence of the other factors. Allouche has been able to identify four regimes that the land-sea breeze patterns can display: the classic circulations with weak synoptic influence, a modulated deep circulation when moderate synoptic forcing drives air masses from sea to land, transitioning to an advection regime with no circulation when the synoptic forcing strengthens, and a much shallower circulation when moderate to strong synoptic forcing drives the air from land to sea. In all regimes, the surface winds blow from sea to land during daytime, and while in the last regime one expects the large-scale land to sea large scale wind to obliterate the circulation, the latter is found to be surprisingly resilient under the conditions simulated by the researchers so far (Fig. 2). The four regimes result in very different air flow patterns that impact environmental quality and wind power potential, among others, at sub-diurnal time scales. While such regimes can in fact be observed under some conditions (e.g. the constant water-ice temperature contrast in the marginal ice zone, another problem Ph.D. candidate Joseph Fogarty is working on in Bou-Zeid's lab), most land-sea breezes display a diurnal cycle due to the daily variation of the land surface temperature). When such realistic unsteady temperature contrasts were imposed by the researchers, a hysteresis cycle with a lag of about 3-6 hours between the driving buoyancy forces and the consequent wind patterns was observed.

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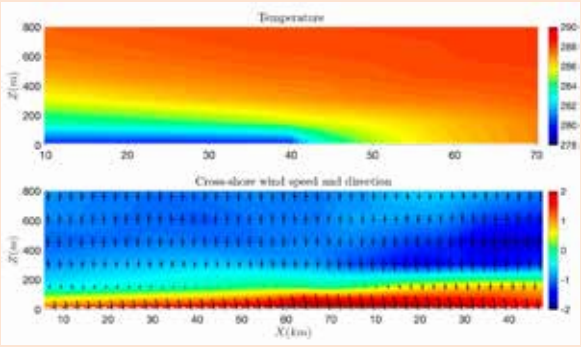

Fig. 2: The shallow but persistent circulation (in yellow to dark blue in the temperature plot at the top, and red to blue in the velocity plot at the bottom) that can be observed when moderate large-scale pressure systems are driving the wind from land to sea. Photo credit Mohammad Allouche and Elie Bou-Zeid

With this improved understanding, the researchers are focusing on how these breezes can be represented in GFDL Earth System Models where the size of a single grid cell may be larger than the circulation. While these models prioritize capturing the larger, planetary-scale dynamics to understand climate change and variability over decades, they are increasingly being solicited to understand local impacts of, and adaptation to, climate change. Coastal areas, where about 40% of the world population lives, will be some of the most affected by changing regional climates and extreme weather patterns. Therefore, an improved ability of Earth System Models to capture or represent small scale processes, such as land-sea breeze patterns, in coastal regions is more critical than ever.

AOS Scientists among World's Most Influential Scholars

Four AOS scientists were recognized on the Web of Science Group's 2021 list of "Highly Cited Researchers." This index identifies global research scientists and social scientists, from more than 70 countries and regions, who have demonstrated exceptional influence – reflected through their publication of multiple papers frequently cited by their peers during the last decade. This determination is based on papers published and cited during 2010-2020 and ranked in the top 1% by citations. According to the Web of Science, this small fraction of researchers "contributes disproportionately to extending the frontiers of knowledge and gaining for society innovations that make the world healthier, richer, more sustainable, and more secure."

Scientific papers are categorized into 21 fields of science. AOS Faculty Members Tom Delworth (GFDL), Steve Griffies (GFDL), and CIMES Deputy Director Gabe Vecchi, professor of geosciences and the High Meadows Environmental Institute, are listed for Geosciences; AOS Faculty Member Larry Horowitz is named for "Cross-Field" impact, reflecting his highly cited publications that span across multiple scientific fields. GFDL Research Oceanographer John Dunne also made the list, for "Cross-Field" impact, as did Andrew Wittenberg, a GFDL physical scientist, who is listed for Geosciences.

Princeton University was well represented, with 27 University researchers listed among the approximately 6,600 world's most influential scholars, including 3,800 Highly Cited Researchers in 21 fields of the sciences and social sciences and about 2,800 Highly Cited Researchers identified as having exceptional performance across several fields.

The methodology that determines the "who's who" of influential researchers draws on the data and analysis performed by bibliometric experts and data scientists at the Institute for Scientific Information at Clarivate, a global leader in providing trusted information and insights to accelerate the pace of innovation.

The full 2021 Highly Cited Researchers list, executive summary, and methodology can be found at Web of Science.

New NSF Grant to Support Asian Americans and Pacific Islander (AAPI) Students in the Geosciences

AOS Faculty Member Sonya Legg, associate director of CIMES, has joined an NSF-funded effort that fosters participation and belonging among Asian American and Pacific Islander (AAPI) students in the geosciences. The project, titled AGILE (AAPI in Geoscience: Inclusivity, Leadership, and Experience), is a multi-institutional collaboration and scholarly network. Brown University and Penn State are the leads of the initiative, with Princeton University among the partner institutions. Through a number of innovative and collaborative programs and events, the project aims to improve the awareness of geosciences among AAPI undergraduates and cultivate a national network of mentors that will boost AAPI participation in geoscience graduate programs and careers.

Legg's role in the project will focus on the Undergraduate Research Internship component that will connect students with meaningful geoscience research and learning opportunities, as part of the intern selection committee. She will also help recruit potential intern project hosts – hopefully some from Princeton and GFDL. Her vast experience with the CIMES intern program will no doubt prove valuable in this endeavor.

"The geosciences, which includes earth system and climate science, impact everyone, and it is therefore important that the geoscience workforce is representative of the whole population, and inclusive and welcoming to people from all affected groups," said Legg. "In national conversations and initiatives to diversify STEM, AAPI students are not usually the focus, because Asian Americans are well represented in many STEM fields. However Asian Americans continue to be underrepresented in geosciences, in contrast to fields like computer science, engineering, and medicine."

The grant, which was formally announced at the American Geophysical Union (AGU) Fall Meeting, funds a number of exciting new initiatives, including a pilot Research Visit Program that will support short visits by faculty, graduate students, and other scientists to AAPI-serving institutions to bring awareness of geoscience careers and graduate school to AAPI students. The project also includes career-development events and workshops, in addition to the Undergraduate Research Internship that will be the primary focus of Legg's efforts. The overarching goal of the project is to expose as many as a thousand undergraduates across the country to geoscience research and careers, establish a new research internship opportunity, and create national cross-career connections between AAPI geoscientists in diversity and inclusion discussions.

"Through this project we aim to introduce AAPI students, who may be majoring in other STEM fields, to the possibilities and opportunities in geoscience, through research internships and scientist visits," said Legg. "I am excited to lend my expertise in developing an internship program through CIMES to this new project, headed by dynamic early career scientists at Brown and Penn State."

The project is being organized by a team of eight scientists from different institutions, with Brown's Department of Earth, Environmental and Planetary Science, and Penn State's Department of Geosciences as the leads. Daniel E. Ibarra (Assistant Professor, Brown University) is the lead PI on the project. He is an isotope geochemist and paleoclimatologist and a co-founder of Asian Americans and Pacific Islanders in Geosciences (AAPIiG). He is a Filipino-American with a commitment to diversifying academia. Kimberly Lau (Assistant Professor, Penn State) is the co-Lead PI, an isotope geochemist and paleoceanographer, and a co-founder of AAPIiG. She is Chinese American and a co-founder of AAPIiG. In addition to Legg, the team also includes David Ho (University of Hawaii at Manoa), Sora Kim (UC Merced), Randye Rutberg (CUNY Hunter College), Jessica Wang (Bellevue College), and Sam Ying (UC Riverside). The majority of the Principal Investigators on the project identify as AAPI and are associated with AAPIiG, a new grassroots, member-driven organization founded by Ibarra, Lau, and Christine Y. Chen (Lawrence Livermore National Lab) in 2020.

Image Credit: AAPIiG

AOS Embraces Diversity, Equity, and Inclusion for Positive Change

The AOS Diversity, Equity, and Inclusion (DEI) Committee is now in its second year and continuing to make strides in fostering an educational and research environment that is more equitable, diverse, and inclusive for all AOS members, including prospective students, alumni, and visitors.

Serving as liaisons between the members of the AOS community and Program administrators, the committee members are actively developing new programs and initiatives that promote a diverse and inclusive community in the AOS Program. The committee includes representatives from across the AOS community: AOS Faculty Members Sonya Legg, CIMES associate director, Gabe Vecchi, deputy director of CIMES, and Stephen Griffies, as well as AOS Postdoc Chloe Gao and Sam Ditkovsky, an AOS graduate student. This past fall, Gao and Ditkovsky replaced AOS Associate Research Scholar Yong-Fei Zhang and Houssam Yassin, an AOS graduate student, who served on the committee in its inaugural year.

Over the past year, continued efforts to bolster and sustain an inclusive culture in the AOS Program have resulted in opportunities for community members to engage in DEI-related training, discussion groups/journal clubs, outreach, and mentorship.

In spring 2021, several members of the DEI committee, along with many others in the AOS Program and Geosciences, 39 in total, participated in GEO/AOS inaugural Unlearning Racism in the Geosciences (URGE) pods. This 16-week, NSF-funded initiative included readings, reflections, group discussions, and policy deliverables (shared on the URGE website) to help diversify and improve inclusivity in the Geosciences.

Forging a close collaborative relationship among students is vital to building a welcoming, safe, and inclusive community. With that in mind, the AOS DEI Committee set up a peer-mentoring program for incoming AOS graduate students in summer 2021. Each of the seven incoming students was paired with a post-generals AOS student and was encouraged to meet with them monthly, over their first year, to help the students navigate Princeton and graduate school. All of the respondents to an anonymous survey distributed in the fall indicated that the program has been useful, according to Legg.

Equally important is the mentor-mentee relationship that has traditionally been at the heart of educating the next generation of Ph.D.s. In prioritizing the Program's mission in support of these relationships in a more equitable and inclusive environment, AOS faculty attended a presentation, in November 2021, on inclusive mentoring by Shawn Maxam, Associate Provost for Diversity and Inclusion at Princeton, arranged by the DEI Committee.

To further efforts to employ a more holistic approach in the AOS graduate admissions process, Legg attended a virtual workshop on holistic admissions, organized by the Inclusive Graduate Education Network, in mid-November and shared with the faculty what she learned prior to the graduate admissions cycle.

"The DEI committee played an important role in ensuring that candidates from historically under-represented backgrounds received full consideration by the AOS faculty," Legg said. The holistic admission process involves viewing the whole application package to evaluate that applicant's characteristics such as intellectual potential, academic preparation, socio-emotional competencies, alignment with program, within the context of the experiences and opportunities available to the candidate, avoiding any rigid metrics such as grade or test score minimums, according to Legg.

Since the 2021 admission cycle, the Program no longer requires the GRE for AOS graduate admissions and diversity statements became an option on both the AOS graduate and postdoc applications.

Additionally, Legg noted that the DEI committee updated the prospective students' webpage in the fall, giving expanded instructions for the Academic Statement of Purpose and recommended inclusion of a COVID impact statement in the AOS postdoctoral and visiting research scientist program applications, which was approved by the VSC.

Other 2021 activities included AOS participation in the GFDL DEI community forums, led by Aparna Radhakrishnan, an AOS professional specialist; Legg held virtual Q&As about the CIMES Intern Program for Bronx Community College (BCC) and Hunter College, in her capacity as CIMES associate director; participation by several AOS community members, among them students and faculty, in Princeton's graduate school

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AOS Embraces DEI continued from Page 12

virtual open houses at the 2021 SACNAS National Diversity in STEM Conference and the National Society of Black Physicists Conference, as well as the AOS/GEO virtual open house for prospective students on December 7, 2021, which was coordinated by the Graduate School.

Gao coordinated the creation of a "happy-to-talk" list for postdocs willing to share their experience with incoming postdocs, which is now shared with all postdocs and will be communicated to all incoming postdocs. Likewise, Ditkovsky is arranging events to encourage interaction between pre-generals students and faculty.

Ditkovsky and Gao also co-organized a Bystander Intervention Workshop for AOS postdocs and graduate students, led by Shawn Maxam, in late January 2022. The workshop provided an overview of bystander intervention best practices and approaches as well as tools to help participants navigate instances of bias and intervene in problematic situations.

"Shawn's presentation discussed biases from the underlying psychology all the way up to concrete examples in a way that strongly resonated with the participants," said Ditkovsky. "We had a good turnout and an enthusiastic response, and students seem open to more programming in the future."

"The DEI workshop idea originally stemmed from a request from a fellow postdoc, that and the attendance at the workshop showed how much the community wanted to be educated and get involved in the initiative," Gao added. "Example scenarios and interactive breakout discussions from the workshop were especially helpful for learning to act and react. We would definitely benefit from having such workshops annually."

The AOS DEI Committee will continue its efforts to build on the Program's existing DEI initiatives and identify opportunities for additional training workshops, outreach, and mentorships. Those engaged in initiatives to improve DEI in the AOS Program are asked to notify the committee so that they can share news of the opportunity with the larger AOS/GFDL community. CIMES funds are available to reimburse expenses associated with DEI-related activities, according to Legg, as are funds to support innovative initiatives to enhance DEI and access through the Department of Geosciences.

"We hope to continue to engage students, postdocs, faculty, and staff in these efforts as new DEI programming, activities, and ideas emerge," said Legg. "Our work is ongoing and requires a sustained effort by all of members of the AOS community."

Sonya Legg and Kaylie Cohanim Ignite STEM Learning

CIMES Associate Director Sonya Legg, an AOS faculty member, and Kaylie Cohanim, an AOS graduate student, believe that science communication and outreach are essential for inspiring the next generation of scientists. On Thursday, November 4, 2021, they put this belief into action at the Boys & Girls Clubs of Mercer County annual youth STEM conference, held at the BGC Mercer Spruce Street Clubhouse.

Legg and Cohanim led "Oceans, Weather, and Climate" workshops for students between fifth and ninth grade, one of ten themed workshops designed to spark youth interest in science, technology, engineering, and math. Fifteen middle-school aged participants attended the oceanography workshops, where Legg and Cohanim conducted hands-on experiments, using water, salt, and food coloring to demonstrate gravity currents, melting icebergs, and atmospheric weather systems, using the GEO rotating tank.

"I was so happy to participate in the MCB&GC STEM workshop in person this year and have the assistance of Kaylie," Legg said. "There was a tremendous amount of enthusiasm and interest in the science we were doing, and it was gratifying to know that we are reaching kids who we may not reach otherwise. I look forward to the event every year."

"I had a great time, I'd love to do it again!" Cohanim said. "Personally, my favorite moments were when the kids realized how much fun science can be. It was a really rewarding experience, especially having the

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AOS Graduate Student Kaylie Cohanim

CIMES Associate Director Sonya Legg

opportunity to interact with youth groups interested in Earth sciences that might not have been reached."

The students, who were encouraged to think like scientists, ended their day eager to ask questions and to listen to career exploration panel discussions on academic and career paths in STEM.

A strong STEM education is becoming increasingly recognized as a key driver of opportunity, but STEM education disparities exist. Local conferences like this play a key role in ensuring the engagement and success of the full diversity of learners in surrounding communities. Over 120 students attended 20 in-person and 15 online workshops.

An annual fall tradition, the Youth STEM Conference is one of many programs offered by the MCB&GC focused on improving youth outcomes in education, developing social emotional competency and leadership skills within the community's youth, with the help of volunteers from neighboring communities.

Alumni News

Check out GFDL's video C-SHiELD: next-generation of extreme weather prediction, which highlight's the work of former AOS Postdoc **Lucas Harris**, a GFDL physical scientist.

Lucas Harris is also a co-organizer of PDC 2022, scheduled for June 1-3, 2022 on Princeton's main campus. Visit the PDC 2022 website to learn more.

Former AOS Postdoc **Karin van der Wiel** (Royal Netherlands Meteorological Institute) was selected for an EGU 2022 Division Outstanding Early Career Scientist Award.

AOS & CIMES News

A recent paper, led by AOS Postdoctoral Research Associate **Henri Drake** presents MARGO, an idealized model of optimally-controlled climate change, which is complementary to both simpler conceptual models and more complicated Integrated Assessment Models. Drake and his co-authors also published an online interactive web application showcasing the model.

Arrivals

Shuai Wang arrived in early January, from Imperial College London, to work with Tom Delworth and Hiroyuki Murakami as an associate research scholar.

Mingyu Park arrived in mid-January, from Penn State, to work with Tom Delworth and Nathaniel Johnson as a postdoc.

William Gregory arrived in late January, from University College London, to work with Mitch Bushuk and Alistair Adcroft as a postdoc.

Yang Wang arrived in late January, from the Institute of Oceanology, Chinese Academy of Sciences, to work as a visiting postdoctoral research associate for 18 months.

Timothy Merlis joined AOS/CIMES in early February as our HPC/Science manager. He comes to Princeton from McGill University.

AOS Alum **Rob Nazarian** is visiting from Fairfield University. He is working with Sonya Legg, his former adviser, through mid-April.