AOS & CIMES Newsletter

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

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AOS Program's Tim Merlis & V. Balaji in Conversation

Tim Merlis

V. Balaji

We recently caught up with CIMES HPC/Science Manager Tim Merlis to talk about his path back to Princeton and his new role in the cooperative institute.

We also chat with V. Balaji who has headed the Modeling Systems Division at GFDL since 2003. Balaji recently accepted a position as a Distinguished Fellow at Schmidt Futures, based in New York.

Advanced computing is essential to research at CIMES. As the HPC/Science Manager for CIMES, Tim Merlis helps develop the scientific vision and strategy for CIMES' computational infrastructure.

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Maya Chung

HMEI-STEP Fellowship Awarded to Chung

AOS Graduate Student Maya Chung has been awarded a 2022 HMEI-STEP Environmental Policy Graduate Fellowship, by the High Meadows Environmental Institute (HMEI), for her project "Integrating Climate and Disease Modeling to Forecast Airborne Disease Risk."

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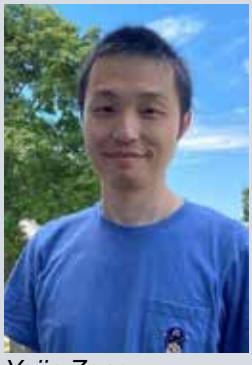

Yujin Zeng

Yujin Zeng Receives CMI Best Paper Award

The Carbon Mitigation Initiative (CMI) recognized Yujin Zeng, an AOS associate research scholar, at the CMI Annual Meeting for outstanding published research.

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Welcome!

We hope your summer is going well and that you are finding some time to relax and recharge. As we prepare for the new academic year, we remain deeply committed to our mission and to the success of every member of our AOS/CIMES community.

In this issue, we speak with CIMES HPC/Science Manager Tim Merlis and V. Balaji, a fixture in the GFDL/AOS/CIMES community. We highlight fellowship/award winners Maya Chung and Yujin Zeng. We share news of upcoming and past AOS/CIMES-sponsored workshops and two additional CIMES Task III awards. We feature a project led by Jim Smith, an AOS associated faculty member. We call attention to our summer internships and an outreach event at the Jersey Shore. Lastly, check out our News section for some cool news about Sarah Kapnick, a former AOS postdoc/CIMES researcher, and Suki Manabe, an AOS senior meteorologist. We welcome all those new to our AOS/CIMES community!

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

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Tim collaborates with CIMES leadership and researchers to advance the CI's scientific mission utilizing its HPC resources, while facilitating novel and innovative research in Earth System Science that explores synergies between GFDL and the University.

He joined CIMES in February 2022.

Can you tell us about yourself? What led you back to Princeton?

I'm a climate scientist and my research has been oriented around climate modeling from the beginning. I was a post-doc at Princeton University in 2011-2013. Then, I went to McGill University, where I was an assistant and associate professor.

Re-joining the scientific communities of Princeton University and GFDL was a great match: I had a desire to be part of a large community of climate researchers and members of this community were excited to have me back to contribute in a new role. There's a lot of mutual familiarity and that helped me hit the ground running!

Can you give us a peek into your role as CIMES HPC/Science Manager?

There are a number of high-impact computational climate science research projects that the Cooperative Institute supports. Several of these make use of a high-performance computing platform that was installed at the university in 2021. This role has some straight-forward management dimensions: intersecting with the excellent computational science and engineering staff of the university to facilitate the work of climate scientists, shaping policies for this unique resource in consultation with members of the university community and folks at the lab, etc.

There are also dimensions of scientific leadership. I've been involved in national and international leadership efforts via professional societies, stuff like chairing committees and organizing an American Meteorological Society meeting. Now, I am offering that scientific vision to major research collaborations. One high-impact project that CIMES is facilitating is a global-storm resolving modeling initiative where atmospheric convection is simulated. This is an exciting collaboration with Kai-Yuan Cheng (CIMES), Lucas Harris (GFDL), Stephan Fueglistaler (Princeton), and Chris Bretherton (Allen AI), among others. Here, we must make judicious choices that are informed by both what is technically feasible and scientifically interesting. This is what is needed for this kind of "big science" and my leadership as a climate scientist, particularly using global atmospheric simulations, is a valuable contribution to the team's effort.

How has the landscape changed for HPC, in the context of climate science, since your days as an AOS postdoc?

There's a continual evolution that is obvious to me on the software side: what seemed new and challenging ten years ago is now totally routine. I remember thinking it felt exotic to use an atmospheric model with an irregular grid… we'll never go back and the supporting software has matured over time.

Overall, I have a fairly pragmatic attitude: at the university, we want to get the research done and we are not going to carefully optimize everything along the way. The folks at the lab setting up production runs of earth system models for Model Intercomparison Projects are naturally going to do more fine tuning to make sure the hardware is optimally used. Again, bringing this know-how to the university community is an opportunity that CIMES can facilitate, building on the ties that have existed for decades.

Finally, the more things change the more they stay the same: one of the primary GFDL clusters, which was brand new when I was a postdoc, has had its hardware replaced many times, but still has the same name ;)

Now that you are working at the convergence of advanced computing and scientific discovery, can you elaborate on the move to support research involving data-intensive computing, artificial intelligence, and machine learning in addition to traditional modeling and simulation?

There's a lot of enthusiasm in the scientific community about the potential for these techniques to advance climate simulation. M2LInES is an important multi-institution machine learning climate initiative where Princeton University's Alistair Adcroft is the Head of Modeling. The university can offer some flexibility on the type of HPC hardware that is available, particularly GPUs, as a result of the focus on research over operations. It's exciting to be helping at that vanguard of our field.

The global-storm resolving modeling initiative that I previously mentioned---which is at a scientific frontier in and of itself---is being leveraged by Allen AI as a training dataset for efforts to capture processes that are too small scale to be simulated using conventional climate models via machine learning techniques. It's wonderful that CIMES is a nexus of these scientific and technical advances, both across the university-GFDL space and in the broader multi-institution context.

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What are you enjoying most about your current position?

It's been a great pleasure to rejoin a large and vibrant community of climate science researchers. I have a profound appreciation of the value of working cooperatively and contributing to science that is done on a scale that is not feasible at other places. But also, just having lunch with people here leads to stimulating, deep discussions of our science: I find that nourishing, pun intended.

Outside of the professional sphere, what do you enjoy doing?

Like many others, I spent more time outside over the pandemic. I did a fair amount of hiking, and this summer I'll try to reach the top of the highest peak in California!

With a background in physics and climate science, Balaji is also an expert in the area of parallel computing and scientific infrastructure. In 2017, he was among the first recipients of the French Government's Make Our Planet Great Again award marking the second anniversary of the Paris Climate Accord. At Schmidt Futures, Balaji will guide expanding efforts at the intersection of the climate and computational sciences.

Can you tell us about your role as the head of the Modeling Systems Group while in Princeton?

The Modeling Systems Group (later Division) was set up in 2002-2003 when GFDL embarked on a program of modernization of the existing models: in particular adapting them to the (then novel) massively parallel computing architectures.

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HMEI-STEP Fellow Maya Chung continued from Page 1

Chung will join fellow 2022 Awardees Lucas Frye, Chemistry; Joseph Lockwood, Geosciences; Erin Phillips, Ecology and Evolutionary Biology (EEB); and Wilson Ricks, Mechanical and Aerospace Engineering (MAE) in exploring emerging topics in environmental policy. The cohort will address the environmental policy implications of their thesis research through supplementary course work and policy-oriented research over the course of the next two years.

Under the advisement of Jessica Metcalf, associate professor of ecology and evolutionary biology and public affairs, Chung's project aims to understand how ENSO influences infectious disease transmission using integrated climate-disease modeling. ENSO events influence temperature, precipitation, and humidity across the globe, which can influence water-, vector-, and airborne disease spread. Previous studies have linked ENSO to several disease outbreaks, but these studies are mostly local and focus on individual ENSO events in hindsight. The researchers hope to leverage physical understanding of ENSO and climate teleconnections to develop longer-lead predictions of regional disease risk. The ultimate goal of this work is to develop forecasts of disease risk and determine which areas of the world are most vulnerable to current and changing climate drivers of disease risk, which may be used to inform proactive health policy and avoid outbreaks.

This work will be a collaboration between Chung, AOS Faculty Member Gabe Vecchi, and their colleagues in ecology and evolutionary biology and public fairs, Professor Jessica Metcalf and Professor Bryan Grenfell.

"I am deeply grateful for this opportunity to explore public policy and the applications of my climate research, both of which I believe are important for climate scientists to understand," said Chung. "I hope this work will bring a global perspective to a local problem, and develop knowledge that can help local governments protect people in a volatile climate."

Chung's primary Ph.D. thesis research focuses on the El Niño—Southern Oscillation (ENSO) and its interactions with ocean salinity and climate change. AOS Faculty Member Gabe Vecchi is Chung's thesis adviser.

Chung joins an impressive group of HMEI-STEP Fellows, many of whom have gone on to pursue positions of environmental leadership in academic, government, nonprofit, and industry sectors following their time at Princeton, including former AOS

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HMEI-STEP Fellow Maya Chung continued from Page 3

Graduate Student Curtis Deutsch who was awarded the fellowship in 2000, former Geosciences Graduate Student Bryan Mignone who was awarded the fellowship in 2001, AOS Graduate Student Ian Lloyd who was awarded the fellowship in 2009, former AOS Graduate Student Joe Majkut who was awarded the fellowship in 2011, former AOS Graduate Student Geeta Persad who was awarded the fellowship in 2013, former AOS Graduate Student Jane Baldwin who was awarded the fellowship in 2015, former AOS Graduate Student Michelle Frazer who was awarded the fellowship in 2016, former AOS Graduate Student Jane Smyth who was awarded the fellowship in 2019, and former AOS Graduate Student Glen Chua who was awarded the fellowship in 2021.

Established in 2000, the program has supported more than 75 HMEI-STEP fellows to date.

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At that time, different research groups at GFDL maintained their independent models, including storied ones like Supersource (Manabe group) and Skyhi (Mahlman group). I was working with Isaac Held on idealized models of convection, then using a model called LAN (limited-area non-hydrostatic).

We decided that to adapt to future architectures we needed to build a common framework for all the lab's models, which we called the Flexible Modeling System, FMS. We also built a common workflow system, called the FMS Runtime Environment, FRE, and instituted basic practices of testing a model (parallel computing can introduce subtle errors, so even seemingly innocuous changes can induce unexpected results). A spectral model used by Isaac for some of his experiments, was the first to become an FMS model. The ocean model MOM came next.

The process was of course not without contention and controversy, but eventually FMS gained acceptance. Director Ants Leetmaa guided the lab gently but firmly through this period.

As an aside, we used to name model versions after cities, Antwerp, Bombay, etc. We named the one where we gained widespread acceptance Damascus, an obscure historical reference you can look up if you're curious!

FMS and FRE were of course too much for one person to handle, and I was encouraged to enlarge the group. Amy Langenhorst, whom we lost long before her time, was the first hire. We soon grew to a group that is now 20+ strong. Starting with Amy, we had a good track record of hiring women and other underrepresented groups, many of whom went on to permanent positions at GFDL. Not one was a token hire.

What did you enjoy most about this position and your time at Princeton/GFDL more generally?

I came here to work on clouds and convection with Isaac, but put up my hand when the head office (Bruce Ross, then Deputy Director) asked for volunteers to dive into the new field of "distributed computing" – GFDL had just acquired a 40-processor parallel computer called the Cray T3E. (For context, Gaea has about 150,000 processors!) I've always been interested in computing in general. Working with other groups gave me the occasion to learn about the land and oceans and so forth as well! I never stopped learning new stuff. People here are extremely collegial and share their knowledge freely. The key for me was to try to grasp the science behind a model, and adapt that to new machines, not just the codes themselves. Many colleagues were open to having a computational scientist propose ideas on how to rewrite their codes. That back and forth, and the limitless learning about the climate system, is my greatest source of growth as a person. And the MSD staff were a constant source of inspiration as well … the weekly meetings were where one would hear the lab's heartbeat.

How has climate modeling evolved since you joined the University and GFDL, particularly in the era of big data and machine learning?

I think we are at a new inflection point as important as the one that inspired my career here, and I hope the lab will seize the opportunity as enthusiastically as we did back in 1998! As I'm fond of saying, we're in an era where *computers get bigger but not faster*. This means we have to rethink our algorithms from the ground up, and yes, machine learning will be a key part of that. Every big model run we make, we have to make it count, by applying ML to the output to extract as much from the patterns as possible. This potentially means completely reinventing the workflow as well, to be able to analyze the data as the model is running.

Can you give us a glimpse into your new role as a Distinguished Fellow at Schmidt Futures?

I have been advising Schmidt Futures for some years, leading an effort to bring philanthropic funding to climate science, through an effort called VESRI. VESRI has funded four

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large international projects, as well as a team (modeled on MSD!) called the Institute for Computational Climate Science at Cambridge to support the science. We're in the process of expanding the institutes in new areas of carbon cycle science and paleoclimate modeling. My role here is to seek new areas for investment in climate science, and shape Schmidt Futures' overall climate portfolio. Big unsolved problems, assembling consortia that are difficult to fund through conventional channels, we will try to plug those gaps. Ideas welcome!

What excites you most about this new position? What do you hope to achieve there?

For myself personally, it's always learning that drives me. I am once again learning about areas of science and technology that are relatively new to me. While philanthropic funding can never replace government funding, we can potentially show the way by funding some high-risk/reward projects that will be catalytic and lead to vitalizing new research areas. I hope it will stimulate the field in good ways.

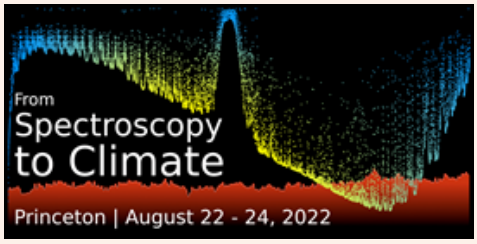
Can you offer some words of wisdom for early-career researchers inspired by your career trajectory?

Thanks for this question! I have had a somewhat unconventional trajectory spanning both science and technology, and am grateful for it. My advice – wisdom might be too strong a word – is not to be afraid to cross disciplinary boundaries: our field, and our world, need it more than ever. "When you come to a fork in the road, take it!", as a wise person once said.

And if you're on the Princeton campus, visit Richard Serra's 'Hedgehog and Fox', outside the Lewis Library, and reflect on its meaning. I have always found it inspiring.

From Spectroscopy to Climate Workshop 2022

The AOS Program, in collaboration with the Princeton Center for Theoretical Sciences, will co-sponsor a 3-day in-person workshop, "From Spectroscopy to Climate," from August 22-24, 2022 at PCTS, Jadwin Hall. The workshop, originally scheduled for June 2020, will focus on radiative constraints on the general circulation and climate.



Although radiative transfer is largely a solved problem, according to Stephan Fueglistaler, AOS Director and workshop organizer, scientists' understanding of the implications for the structure of the general circulation remains incomplete and deserves further study. As such, the workshop focuses on recent advances bridging spectroscopic considerations to climate dynamics.

"Part of the motivation for this workshop is to clarify, and provide a good intuitive understanding of the role of, spectroscopic properties of gases in the atmosphere for climate as we know it," Fueglistaler said.

CIMES HPC/Science Manager Tim Merlis is a co-organizer of the event.

Confirmed speakers, including Dennis Hartmann (University of Washington), Alison Ming (Cambridge University), Keith Shine (University of Reading), Jacob Seeley (Harvard University), Joao Teixeira (Jet Propulsion Laboratory), and Nadir Jeevanjee (GFDL) will offer differing perspectives on the topic.

The workshop program includes invited talks, a poster session, and daily student-led summary discussions, followed by a Q&A session.

The registration deadline has passed. For further information, contact Stephan or Tim.

Awardee Yujin Zeng continued from Page 1

Zeng was awarded the Robert H. Socolow Best Paper Award for Postdoctoral Fellows for his CMI-supported paper, "Possible anthropogenic enhancement of precipitation in the Sahel-Sudan savanna by remote agricultural irrigation," which was published in the journal Geophysical Research Letters in March. His co-authors included Elena Shevliakova, a GFDL senior climate modeler, and Sergey Malyshev, a GFDL professional specialist.

The paper used an earth-system model to examine the impact of expanded agricultural irrigation on precipitation in remote areas. The researchers found that irrigation in the Middle East and South Asia may enhance rainfall in a large portion of the Sahel-Sudan savanna that spans Africa south of the Sahara Desert. This enhancement arises through a change in the large-scale patterns of atmospheric moisture and temperature that exist from the Sahara to the tropical rainforests of Central Africa.

The study found that rainfall in the savanna was magnified to a similar extent as other human-made climate drivers such as greenhouse emissions suppress precipitation. This means that the expansion of irrigation in far-off regions should be considered as a possible factor affecting the risk of drought and famine in the Sahel-Sudan savanna. In addition, the region's future water security could be affected by water management and ongoing groundwater depletion in South Asia and by the pace of rehabilitation of the war-damaged irrigation infrastructure in the Tigris-Euphrates valley.

The award is named in honor of Robert Socolow, professor of mechanical and aeronautical engineering, emeritus, at Princeton and the co-director of CMI from 2000-2019. CMI is an independent academic research program based at Princeton and administered by the High Meadows Environmental Institute (HMEI) that includes 16 principal faculty investigators and over 50 research staff.

CIMES Awards Two Additional Projects

The Cooperative Institute for Modeling the Earth System (CIMES) has announced awards now totaling $702,000 to support nine 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 two additional recently funded projects are:

Titrating the Impact of Low and High Frequency Perturbations of Transmission of Infectious Disease: Positioning the Role of Climate

The climate can affect the transmission of infectious diseases. Cold temperatures increase the transmission of some viruses like SARS-COV-2, rain can modulate breeding opportunities for important vectors (e.g., mosquitos) of malaria, flooding may increase the range of exposure of pathogens like cholera, and so on. All of these climate drivers change over the course of years and decades. Seasonal fluctuations are the most salient, with repeatable patterns occurring over the course of a year, but there are also multi-annual cycles, such as El Nino. These changes will intersect with the fact that exposure to many infections is immunizing, so that once infected, individuals are protected, at least for some period of time from reinfection. This will mean that increases in transmission (driven by the climate) will be followed by depletion of susceptible individuals who can acquire the infection, and thus reduce the spread of infection. In this project, a team of researchers, led by Jessica Metcalf, associate professor of ecology and evolutionary biology and public affairs, will explore how this fluctuating depletion of susceptible individuals intersects with fluctuations in transmission to shape the course of epidemics over short and long time-scales. The team will focus their analysis on simulations (to explore the range of the possible) alongside probing data on the drivers of respiratory syncytial virus (a directly transmitted childhood infection) and dengue (a vector born infection) to understand how climate effects on transmission and the dynamics of susceptibility intersect to shape the burden of infection under current and future climates.

Team Members: Jessica Metcalf, EEB, School of Public and International Affairs; Bryan Grenfell, EEB, School of Public and International Affairs; Keith Dixon, NOAA/GFDL; Gabriel Vecchi, GEO, HMEI; Rachel Baker, HMEI; Jamie Caldwell, HMEI; Inga Holmdahl, HMEI

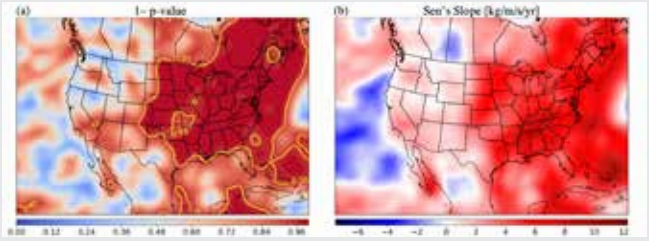
Ice-Ocean Interactions: Impact of Ice-Shelf Basal Melting and Temperature Structure on Ice-Shelf Basal Crevasses

Ice-shelf basal crevasses play important roles in ocean dynamics by impacting the iceberg size distribution and modifying the drag of the ocean currents flowing past the ice-shelf cavity. On the other hand, melting at the ice-ocean interface can also impact the stability of basal crevasses. To assess the future structural integrity of ice shelves, we must build our understanding of physical mechanisms triggering unstoppable full-depth crevassing near the calving front. In this project Ching-Yao Lai, assistant professor of geosciences and AOS, will collaborate with GFDL scientists to use deep neural networks (NN) to detect rifts and the surface expression of basal features using multiple high-resolution remote-sensing datasets. The team will also leverage continent-wide rift observations to develop mechanistic understanding of how ice-shelf temperature and ice-shelf basal melting impact crevasse stability. The researchers aim to couple data-driven methods with physics-based modeling to advance our understanding and predictions of the destabilizing mechanisms of ice-shelf basal crevasses.

CIMES Award Highlight

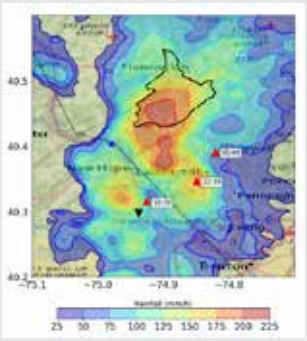
Extreme Rainfall and Flooding

The potential for increasing rainfall extremes in a warming climate is a major concern for many regions of the US and around the world. In the project "Hydrometeorology of Extreme Rainfall and Flooding", Yibing Su (PhD student in Civil and Environmental Engineering) and Jim Smith (William and Edna Macaleer Professor of Engineering and Applied Science) examine extreme rainfall in the US from an atmospheric water balance perspective. Key elements of extreme rainfall are the amount of water vapor in an atmospheric column, known as the precipitable water, and the transport of water vapor by the winds. Precipitable water has been a central player in hydrometeorological studies of rainfall extremes and for engineering design of high-hazard structures. Water vapor transport has received increasing attention through analyses of Atmospheric Rivers, which are long, narrow regions of extreme water vapor transport embedded in extratropical cyclones. The results of Su and Smith point to atmospheric water vapor transport and Atmospheric Rivers as central ingredients of rainfall extremes in a warming climate.



Trends in water vapor flux over the conterminous US: regions of significant increasing trends (dark red) are shown on the left, magnitude of trends in kg/m/s/year are shown on the right.
From Su and Smith, An atmospheric water balance perspective on extreme rainfall potential for the contiguous US, Water Resources Research, 57, e2020WR028387, 2021.

Extremes of the atmospheric water balance are examined through statistical methods based on Extreme Value Theory and long atmospheric water balance data sets derived from North American Regional Reanalysis fields. Analyses suggest that the storage term in the atmospheric water balance, precipitable water, is bounded, in line with conventional hydrometeorological tools used from engineering design. Over significant portions of the US east of the Rocky Mountains, however, extreme value analyses point to unbounded distributions for water vapor transport. Because water vapor transport provides the dominant term in atmospheric water balance representations of extreme rainfall, unbounded extremes of water vapor transport point to difficulties in conventional hydrometeorological analyses of design storms. Extreme value analyses also point to the role of extreme storms, principally tropical cyclones and Atmospheric Rivers, in determining whether atmospheric water balance components are bounded or not. Extremes of both precipitable water and water vapor transport show increasing trends over much of the US during the past four decades.



Rainfall rate (mm/h) field at 2240 UTC on September 1, 2021 from the remnants of Hurricane Ida. Inverted black triangle shows the location of the Upper Makefield tornado at 2230 UTC; red triangles show locations of supercell thunderstorm that produced the Upper Makefield tornado and record flooding over the Neshanic River (outlined in black).

The Lower Mississippi River has seen a sequence of major floods over the past 15 years. Major flooding in the Lower Mississippi River, as represented by operation of the Bonne Carre Spillway which protects New Orleans, has occurred 8 times since 2008, equal to the number of times the spillway was operated during the previous 70 years. The increased frequency of flooding in the Lower Mississippi River is paired with significant increases in extremes of atmospheric water vapor transport over the basin. The agents of extreme water vapor transport, and the associated extreme rainfall and flooding in the Lower Mississippi River, are Atmospheric Rivers. Record flooding in the Lower Mississippi River in April and May of 2011 resulted from extreme rainfall delivered by a sequence of 9 Atmospheric River episodes. Su and Smith found significant increases in the annual count of Atmospheric Rivers from 1950 to 2015 over the Mississippi River basin. Climate variability plays a significant role in the temporal clustering of Atmospheric River occurrences; major floods in the Lower Mississippi River, like the 2011 flood, are associated with unusually large numbers of Atmospheric River episodes.

On September 1, 2021, the remnants of Hurricane Ida transformed into a lethal new variant of tropical cyclone in which unprecedented short-duration rainfall from clusters of supercell thunderstorms produced catastrophic flooding in watersheds of the Northeastern US. Like other extreme flood events in the Northeastern US, Extratropical Transition was a key element of extreme rainfall from Ida.

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CIMES Award Highlight continued from Page 7

Tropical and extratropical components of storm evolution contributed to extremes of water vapor transport, which played a central role in controlling rainfall extremes in Pennsylvania, New Jersey, and New York.

Assessing and enhancing the capabilities of Earth System Models to simulate extreme rainfall is a principal objective of the project. Close examination of Hurricane Ida pairs polarimetric radar studies, atmospheric water balance analyses and simulation studies using the GFDL SHiELD (System for High-Resolution Prediction on Earth-to-Local Domains) modeling system. These analyses will be used to assess the predictability of short-duration rainfall extremes in both current and future climates.

Summer Internships Forge Ahead In-Person

For the first time since 2019, a vibrant community of undergraduates with curiosity and a passion for science are working in-person alongside the researchers in Sayre Hall and GFDL.

Six undergraduates from colleges all over the United States, from California to Puerto Rico, and two Princeton University undergraduates are spending this summer as CIMES interns and HMEI interns, respectively, working on project-based research in atmospheric, oceanic, and earth system science. An additional Princeton University undergraduate intern is working on the Forrestal Campus with support from the Andlinger Center for Energy and the Environment (ACEE).

This summer's CIMES cohort is part of the CIMES Research Internship Program, which was initiated in 2016, under the Program's predecessor CICS, and 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.

After two years of seeing interns and hosts in Zoom blocks, welcoming interns back to the Forrestal Campus turns out to be an invigorating and hopefully transformative experience. For eight weeks this summer, the students – all undergraduates – are immersing themselves in individual research projects under the mentorship of their GFDL/AOS hosts. These practical experiences beyond the classroom often give the students, who bring a variety of perspectives and lived experiences, a competitive edge in preparing for graduate school and potential careers in collaborative academic and research environments.

"Having the CIMES interns here in-person this summer harkens back to the days before the pandemic when community and connection were at the heart of the Program," said CIMES Associate Director Sonya Legg. "I am grateful to our volunteer hosts who have crafted opportunities for in-person collaboration as well as social interaction, despite this continued state of flux. All of them are deeply committed to supporting diverse talent in the climate sciences."

"We also have a great group of interns again this summer, who bring boundless enthusiasm to their projects and to our campus community," Legg said.

Allan Cruz (University of Puerto Rico), under the mentorship of Ming Zhao and Steve Garner, is exploring A Study of Changes in Atmospheric Blocking Statistics in Response to Global Warming Using GFDL GCMs; Juleanna De La Cruz (UCLA), under the mentorship of Alex Huth and Olga Sergienko, is examining Interactions between Ice shelves, Calving, Icebergs, and Climate; Josephine Elumeze (LaGuardia Community College), under the mentorship of Tom Robinson, is immersed in a Climate Cloud Containers Continuous Integration Continuous Delivery (C5-id) project; Gavin Fry (Dartmouth University), under the mentorship of Bor-Ting Jong and Tom Delworth, is researching the Increase in the U.S. Northeast Extreme Precipitation: Past, Present, and Future; Maximus Sasser (University of Oklahoma), under the mentorship of Mingjing Tong, is Evaluating Observation Innovation of Surface Temperature and Humidity for the Assimilation of the Observations in GFDL SHiELD Model; and Megan Schaaf (University of Wisconsin), under the mentorship of Baoqiang Xiang, is Tracking the Origins of the Forecast Errors for the Madden-Julian Oscillation. As in past years, their summer projects span a range of research conducted at GFDL and CIMES.

Building on the success of the past two summer's virtual experience, CIMES interns and hosts have also created an online community through a slack channel, according to Legg, and are participating in interactive, hybrid climate science tutorials, in addition to informal in-person social gatherings.

The HMEI interns are also working in-person this summer with AOS hosts under the auspices of HMEI's Environmental Internship Program, which offers Princeton undergraduate students the opportunity to complement their academic course of study with hands-on research and project experiences during the summer months.

Yi Jin Toh '25 is working with Marion Alberty, Graeme MacGilchrist, and Curtis Deutsch on marine heatwaves and their impact on ocean biology, and Saumya Malik '24 is working with Mitch Bushuk, Graeme MacGilchrist, Alexander Haumann, and Curtis Deutsch to address the question, "Can we predict primary production in the ocean?"

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AOS Program Workshop to Address Extreme Event Attribution

AOS students and postdoctoral researchers will gather on Princeton's Main Campus from August 3-5 to immerse themselves in a student-led summer workshop, generously funded by a portion of AOS Senior Meteorologist Isaac Held's BBVA Foundation Frontiers of Knowledge Award.

The occasion will be the "Attribution of Extreme Events to Climate Change" workshop, the tenth in a series of annual summer workshops aimed at bringing together the next generation of students and early-career researchers for three days of in-depth scientific discussion and interaction on a climate-related topic decided on by the AOS graduate students. The workshop, to be held in Guyot Hall, will be broadly centered on the topic of attributing extreme events to climate change, with each speaker approaching the topic from their own perspective.

The invited plenary speakers include: Freddy Bouchet, ENS de Lyon and CNRS; Deepti Singh, Washington State University; and Hiroyuki Murakami, UCAR and NOAA/GFDL.

A physicist and leader of the Climate and Statistical Mechanics Group at France's National Centre for Scientific Research, Freddy Bouchet's research focuses on climate dynamics phenomena, specifically related to turbulence, climate extremes, and large scale dynamics of atmospheres and oceans; developing algorithms aimed at computing rare events in complex dynamical systems; and studying fundamental questions in statistical mechanics and dynamical systems theory.

A climate scientist and an assistant professor in the School of the Environment at Washington State University Vancouver (WSUV), Deepti Singh's research explores the physical drivers of climate extremes, and their impacts on agriculture, water availability, and human health. She combines a variety of tools including observations, paleoclimate evidence, remote sensing data, and model simulations, to study extremes in the past and future climates. She is particularly interested in studying extremes such as intense rainfall, droughts, and heat waves in monsoonal climates that affect the billions of people with relatively poor adaptive capacity living in these regions. Singh will also discuss some of her current research on compound extremes.

A project scientist at the University Corporation for Atmospheric Research (UCAR) and NOAA/GFDL, Hiroyuki Murakami's research interests include tropical cyclone climate projections and predictions; extreme hydroclimate events; and numerical weather prediction, with a particular emphasis on the effect of anthropogenic climate change on extreme weather events, which in turn leads to guiding climate change adaptation.

Building on the success of the Program's previous workshops, the 2022 workshop will connect these expert climate scientists from the larger scholarly community with AOS students and postdocs with the goal of providing a snapshot of the current state of this relatively new branch of climate science. Workshop organizers anticipate that the workshop's informal setting will foster discussion and the active exchange of ideas.

The structure of the 2022 workshop will follow a similar format as last summer's well-received virtual event, featuring a combination of lectures, tutorials, and opportunities for interaction between the speakers and the AOS/GFDL community. Student organizers actively plan and host the highly-interactive event, using the opportunity to extend the bounds of intellectual engagement. The return to an in-person format presents an added opportunity for informal, social interactions and interpersonal exchanges over meals and breaks.

Each day will involve seven hours of planned activities. In addition to the four plenary lectures, open to the entire AOS/GFDL community, the interactive workshop will include blackboard-style lectures and hands-on tutorials for AOS students and postdocs. Informal social events between students and invited speakers are planned, as is a panel discussion between the speakers and the wider AOS community. An AOS/GFDL scientist will moderate the discussion, with both invited speakers and AOS/GFDL scientists serving as panelists.

Questions related to the upcoming workshop may be directed to members of the workshop planning committee: Sofia Menemenlis, Cameron MacDonald, and Allison Hogikyan.

In Cased You Missed It ... PBS Piece on Hurricanes, featuring AOS Faculty Member Gabe Vecchi, deputy director of CIMES, and Hiroyuki Murakami (UCAR/GFDL)

At Long Last, PDC 2022

Held at Princeton University and co-sponsored by the Cooperative Institute for Climate Science (CIMES) and GFDL, the 4th Workshop on Physics-Dynamics Coupling in Weather & Climate Models (PDC22) brought together a burgeoning worldwide community of scientists who have an interest in discussing and improving process coupling in geophysical modeling. The workshop was held June 1-3 on Princeton's Main Campus in the Frick Chemistry Laboratory, with 35 in-person attendees, and virtually with more than 80 remote attendees.

GFDL Physical Scientist Lucas Harris, a member of the 2022 organizing committee, said that the gathering was originally scheduled for June 2020, but was canceled because of the COVID-19 pandemic. Instead of turning the workshop into a wholly virtual meeting, the workshop organizing committee postponed it again in 2021, holding out for a moment when they could harness the synergy between in-person and virtual participants.

"It was really exciting for all of us to finally be able to get together after so much time spent seeing one another on computer screens," said Harris. "For most of the attendees and speakers this was the first in-person meeting they had been to in three years. This gave many of us the ability to have one-on-one or small group conversations that are impossible in a virtual meeting. Having the workshop in the spectacular Frick building made the workshop feel particularly special."

Although the 2020 and 2021 workshops never materialized, the pandemic didn't stop this community of scientists from growing in the lead up to the 2022 iteration, according to Harris. PDC22 became the ideal forum for these scientists to share their ideas and perspectives, with the aim of gleaning new insights into physics-dynamics interactions and coupling techniques.

Physics-dynamics coupling is a challenging, complex, and evolving modeling problem for nearly all practitioners in the weather, climate, and Earth system model communities. Improving current models and developing new ones requires deep understanding of how model components work together, a strong consideration of the practical scientific and computational aspects of modeling, and constant guidance and learning from the broader modeling community in addressing this multifaceted challenge.

Connecting scientists, particularly early-career scientists interested in model development, to one another gives them the opportunity to shape this emergent field. AOS Graduate Student Chenggong Wang was one of several researchers from AOS and CIMES who attended the meeting.

"The PDC22 workshop connected me to the model development community and their latest research," said Wang. "I learned how this community has been improving the speed, accuracy, and scientific understanding of our best tool—climate models, which many climate scientists are using every day to understand complex earth systems."

The workshop provided a platform for a free exchange of ideas and experiences on topics of importance to the complexities of the issue. This included the traditional perspective of coupling atmospheric dynamics to physical parameterizations but has also extended to coupling to atmospheric chemistry and between different components of the earth system. Presentation topics included numerical techniques for coupling dynamics, physics, dust, chemistry, and the land-ocean-atmosphere interface; new techniques and frameworks for integrating these components; fundamental mechanics, thermodynamics and energetics in geophysical models; new accuracy and error analyses for component coupling; and the practical implications of these changes in a wide array of weather and climate modeling applications.

CIMES Researchers Linjiong Zhou and Yi-Hsuan Chen were among the workshop presenters, with talks on Integrated Dynamics-Physics Coupling in GFDL-SHiELD and Exploring Two Coupling Strategies of the Boundary Layer and Convection Schemes in GFDL AM4, respectively. Other presenters included Princeton AOS alumni Shian-Jiann Lin, Jane Baldwin, and Spencer Clark, and former AOS postdocs Xi Chen, Brandon Reichl, and John Wilson.

PDC 2022 was dedicated to the memory of Professor Markus Sebastian Gross, who unexpectedly passed away in January 2022. He founded the PDC workshop series and was a leader in the Physics-Dynamics Coupling community, having published the defining article in the field. His vision brought light to the significance of the coupling problem to a larger community and established it as a field worthy of serious scientific study.

Summer Internships continued from Page 8

"Yi Jin Toh has been working on understanding the impact of marine heatwaves on primary production in the ocean," said MacGilchrist. "She has written some really nice code that aligns model data when marine heatwaves are happening and visualizes how different processes may lead to increases or decreases in primary production. Jin, whose interests are at the boundary of computer science and ecology, has been a real joy to work with, writing careful and meticulous code that will be of huge benefit to the project moving forward."

"Saumya Malik has been calculating the "potential predictability" of parameters in the marine ecosystem, based on GFDL models," MacGilchrist said. "She's found that primary production, chlorophyll, sea-surface temperature and a host of other important parameters have the potential to be predictable months and even years in advance, but that there's a lot of differences across the globe. Saumya. whose background is in computer science, has made amazing progress over the first half of her internship, reproducing results from a recent paper on the topic. The next few weeks will be an exciting exploration of new findings."

In addition to the CIMES and HMEI interns, ACEE Intern Freddie Furia '24 is working with Legg and Visiting Postdoc Henri Drake, over the summer, focusing on Climate Impacts of Ocean Thermal Energy Conversion (OTEC). "OTEC is a technology that uses naturally occurring thermal gradients in tropical oceans to generate zero-emissions renewable energy," Drake said. "Freddie is programming an OTEC submodule within GFDL's computational ocean model to explore the impact that this large-scale energy extraction could have on regional and global climate."

All of the hosts share a deep commitment to making CIMES and AOS a fully welcoming and supportive environment for the student interns, who are committed to making the most of their experiences. By summer's end, these students will have gleaned enough knowledge and confidence to present their own scientific research and developed personal connections that will long outlast their time in Princeton.

2022 SOCCOM Annual Meeting

For the first time in three years, the Southern Ocean Carbon Climate Observations and Modeling (SOCCOM) project held its annual meeting at Princeton from June 15 to 17. 30 participants in the multi-institutional project, originally lead by founding director Jorge Sarmiento of AOS, attended in person, and another 70 researchers and program managers joined the hybrid meeting virtually to hear about the initiative's progress and plans for the future. The meeting was a long-awaited opportunity for many team-members to reconnect in person, and the setting in Lewis Library's seminar room 120 allowed for robust discussion with virtual participants from around the world as well.

SOCCOM 2022 Annual Meeting Participants

Having just completed its eighth year with renewal funding for the next two years, SOCCOM has 113 deep-diving autonomous biogeochemical floats currently collecting oxygen, nitrate, pH, and optical measurements in the Southern Ocean. This is down from 156 floats in operating in summer of 2020 due to a lack of cruise opportunities to replenish the array during the pandemic. Float production has continued, however, and there is a store of floats ready to be deployed on upcoming Southern Ocean cruises to restore array coverage.

The meeting featured two keynote presentations. To help inform a new SOCCOM project to deploy floats in the shallow Ross Sea, Walker Smith (Virginia Institute of Marine Science/Shanghai Jiao Tong University) provided an overview of the physical characteristics and biology of the region and considerations for float placement. As participants considered future directions for SOCCOM research, Stephen Riser, Observations Co-Lead (UW), gave an overview of novel Argo and BGC-Argo studies that have expanded the space and time scales originally expected to be addressed by the arrays.

Walker Smith (VIMA) presenting "SOCCOM in the Ross Sea: Challenges and Opportunities."

Additional science presentations focused on air-sea fluxes and their impacts, nutrient cycling and production, ice interactions, the role of eddies, and changes in inventories, circulation and mixing. Moderators and presenters included SOCCOM Principal Investigator Curtis Deutsch (AOS), SOCCOM Associate Director Ken Johnson (MBARI) and current and former AOS researchers Joellen Russell (Modeling Lead - University of Arizona), Alison Gray (UW), Seth Bushinsky (University of Hawaii), Benjamin Taylor (UCSD), and Alex Haumann (AOS), who reported on progress in observational and modeling advances and new science opportunities.

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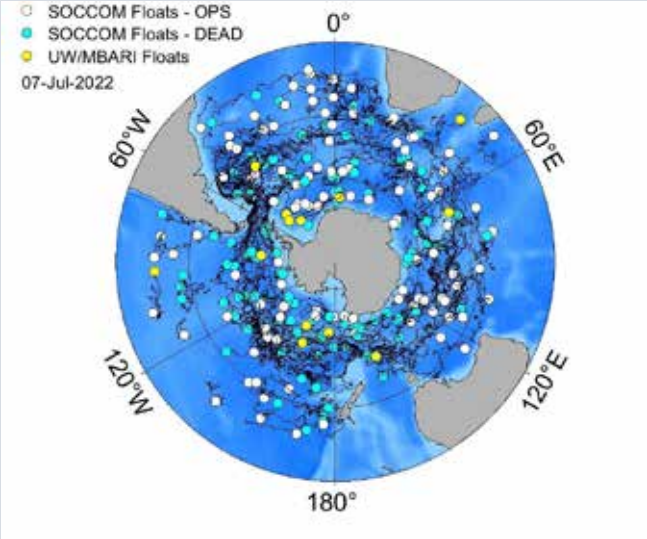
The SOCCOM Project was launched in 2014 with the goal of improving our understanding of the role of the Southern Ocean in climate change and biogeochemistry. SOCCOM's circumpolar network of autonomous profiling floats with biogeochemical sensors and its biogeochemical Southern Ocean State Estimate (B-SOSE) are being used to describe carbon, oxygen, nutrient and productivity cycles of the Southern Ocean and their relationship to physical processes. Since the program's inception, SOCCOM floats have collected over 23,000 profiles, making the Southern Ocean, arguably one of the harshest marine environments on Earth, the best-observed region of the ocean in terms of biogeochemistry.

SOCCOM is supported by the National Science Foundation (NSF).



SOCCOM float profile locations and trajectories. White = operational, Blue = non-operational, Yellow = UW/MBARI float

AOS/CIMES Scientists Turn Out for Ocean Fun Days 2022

Sunny skies welcomed throngs of young families to the 19th annual Ocean Fun Days at the Jersey Shore for a weekend of interactive fun and education on Saturday, May 21, at Island Beach State Park, and on Sunday, May 22, at the New Jersey Sea Grant Consortium (NJSGC) on Sandy Hook. This was the first in-person event since 2019.

Ocean Fun Days fosters scientific curiosity in New Jersey's youth and promotes coastal and environmental stewardship, encouraging them to discover the relevancy of science in their everyday world. It also provides an avenue for scientists to engage broader audiences in their work and improve their informal science communication skills.

CIMES Associate Director Sonya Legg, an AOS faculty member who coordinated the 2022 outreach effort at Princeton, was joined by AOS Research Scholar Spencer Hill (CIMES), Yushi Morioka, an AOS/CIMES visiting research scholar, Aakash Sane, an AOS postdoc, AOS Graduate Student Sofia Menemenlis, Yang Wang, an AOS/CIMES visiting postdoctoral research associate, and AOS Postdoc Akshaya Nikumbh (CIMES) at the CIMES/AOS exhibit to facilitate hands-on/minds-on STEM activities, including iceberg melting, tornado-in-a-bottle, and a DIY rotating tank, contributed by Hill.

"It was especially nice to have Spencer and Yushi contributing their outreach experience," said Legg. "Spencer's DIY rotating tank (made with Lego pieces and a lazy Susan) allowed us to demonstrate how the earth's rotation fundamentally changes the character of the fluid motion in the atmosphere and ocean."

L to R: Spencer Hill and Yushi Morioka

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Ocean Fun Days continued from Page 12

"Rotating tanks are a powerful teaching tool from elementary through graduate school levels," Hill said, "from generally inspiring students to pursue STEM to rigorously teaching the physics of planetary fluid flows that underlie weather, climate, ocean circulation, and planetary interior fluid motions."

The DIY rotating tank is a much smaller and more portable version of rotating tanks used in experiments in the Geoscience Department's lab, according to Legg, and an effective tool in helping event attendees of all ages learn more about geophysical fluid dynamics and the world around them.

"I had a great time using our DIY rotating tank to teach the basics of our rotating oceans and atmosphere at the Saturday event, and it's even better that the group used the device on the Sunday event as well," said Hill. "The tank's portability and ease of use really shone in these cases where we were outside and without a direct power source, and it was especially nice as a trio along with Yushi's and Sonya's demonstrations."

"Yushi's tornado-in-a-bottle experiment is one kids can easily make at home, but demonstrates important principles of conservation of angular momentum and vortex generation," Legg said.

"I am surprised to find that most of the local kids know the tornado phenomena," said Morioka. "Once they start the experiment, they look like little scientists showing curiosity about what is happening in the bottle."

Display tables were packed with children and families eager to try their hand at tabletop scientific inquiry and even more so at the NJSGC on Sunday, when marine scientists, researchers, and environmentalists scientists were not competing with the allure of the beach.

Shaped by storms and tides, Island Beach State Park is a narrow barrier island stretching for 10 miles between the ocean and Barnegat Bay. It is one of New Jersey's last significant remnants of a barrier island ecosystem and is one of the few remaining undeveloped barrier beaches on the north Atlantic coast.

The researchers, most of whom had never participated in Ocean Fun Days, quickly became adept at fielding questions not only from the children, but also from inquisitive adults at both Island Beach State Park and the historic Fort Hancock section of Sandy Hook, home to NJSGC headquarters.

"I enjoyed talking with everyone who came by, and the kids had fun with the hands-on experiments," Menemenlis said. "Both kids and parents asked lots of interesting questions, often about oceanic and atmospheric analogs to the tabletop models: for example, what do the bottles in the tornado-in-a-bottle experiment represent, or what would happen to weather if the Earth wasn't spinning."

Sofia Menemenlis

"It was nice to see kids' curiosity and their enthusiastic responses to our questions," said Nikumbh.

"Explaining a concept to a general audience allows us to view it from a simple perspective and understand it better," she said. "This opportunity was a good reminder to revisit research ideas with the simplest possible explanation."

Akshaya Nikumbh

In addition to the nearly 50 exhibitors, eco-friendly activities included coastal crafts, fiddler crab races, guided eco-tours, workshops, using seines to net fish and other aquatic life, an energy scavenger hunt, hand painting, and games.

The two-day event was made possible through the generous support of New Jersey Natural Gas and the New Jersey Sea Grant Consortium, an affiliation of colleges, universities and other groups dedicated to advancing knowledge and stewardship of New Jersey's marine and coastal environment. Additional sponsors of the event included NOAA, NJDEP Division of Parks and Forestry, Gateway National Park – Sandy Hook, and the Asbury Park Press.

Alumni News

Former AOS Postdoc and CIMES Researcher **Sarah Kapnick** was named NOAA's chief scientist on July 7, 2022. Kapnick will serve as the senior scientist for the agency, advancing policy and program direction for NOAA's science and technology priorities. She is the third woman in NOAA's history to be appointed to this role. Learn more

Photo: NOAA

Former AOS Postdoc **Rebecca Asch** (East Carolina University) was the recipient of the Dean's Early Career Award at her university and has also been named a Kavli Fellow.

AOS Alum **Rob Nazarian** (Fairfield University, Dept. of Physics) received the 2022 Award for Distinguished Student Advising and Mentoring in the College of Arts and Sciences.

AOS & CIMES News

AOS Senior Meteorologist **Suki Manabe** has been honored as one of America's "Great Immigrants" by the Carnegie Corporation of New York in the philanthropical organization's annual July 4 awards. Learn more

Photo by Denise Applewhite

Arrivals

Marco Corrales-Ugalde joined the Program in mid-April to work with Jessica Luo and Charlie Stock as a postdoc. He comes to Princeton from the University of Oregon.

Zack Labe arrived in early May, from Colorado State University, to work with Nate Johnson and Tom Delworth as a postdoc.

Benjamin Le Roy arrived in early May, from the French National Centre for Scientific Research (CNRS), to work with Keith Dixon as a postdoc.

Gabriel Lau, a former faculty member and GFDL scientist, arrived in mid-May to work as a senior scholar.

Marina Hirota arrived in mid-May, from the Federal University of Santa Catrina, to work with Elena Shevliakova as a visiting research collaborator.

Tristan Abbott arrived in early June, from MIT, to work with Yi Ming as a postdoc.

Pablo Zurita-Gotor, a returning faculty member from the Complutense University of Madrid, arrived in mid-June. He is working with Isaac Held throughout the summer.

Matthew Lobo, one of our new graduate students, arrived in early July. He will be advised by Bob Hallberg.

Departures

Abigail Lute left the Program in late April to work at the Woodwell Climate Research Center as a postdoctoral researcher in Physical Climate Risk.

Sarah Schlunegger left the Program in late May.

V. Balaji left the Program in early June. He accepted a position as a Distinguished Fellow, Schmidt Futures.

Hyung-Gyu Lim left the Program at the end of June to work as a research scholar at the University of California, San Diego.

Isabel Martinez-Cano, an HMEI associate research scholar who worked as a CIMES researcher, left the Program at the end of June.

Kai-Chih Tseng left the Program at the end of June. He accepted a position as an assistant professor at National Taiwan University.

Rebecca Beadling is leaving the Program at the end of July. She accepted a tenure track assistant professor position in the Earth and Environmental Science Department at Temple University.

A Perfect Day for a Photo Op! 2022 CIMES Interns

L to R: Max Sasser, Allan Cruz, Gavin Fry, Josephine Elumeze, Jules De La Cruz, Megan Schaaf

CIMES