



AOS & CIMES Newsletter

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



Winter 2021

Volume 15 Number 1

New Supercomputer Poised to Change the Face of Earth System Sciences Research



Photo Credit: Kevin Abbey,
PICSciE systems administrator

“A ‘Stellar’ boost of computational energy arrives at Princeton University to advance the Princeton/AOS - NOAA/ GFDL collaborative research in the numerical modeling of Planet Earth’s weather and climate, which will lead to discoveries, improved understanding and predictions of the Earth system.”

~ GFDL Director V. Ramaswamy

Sifting through vast amounts of data at incredible speeds, supercomputers have become essential tools in tackling the critical scientific challenges and societal concerns of our time. In response to a growing demand for advanced high-performance computing in scientific research, the Cooperative Institute for Modeling the Earth System (CIMES), with funding from the National Oceanic and Atmospheric Administration (NOAA), has acquired the University’s newest supercomputer, dubbed Stellar, to accelerate further scientific discovery in Earth system sciences research.

Continued on Page 2

AOS Committed to Diversity, Equity, and Inclusion



Formed in the fall of 2020, as an outgrowth of conversations held over the summer surrounding racial justice, the AOS Diversity, Equity, and Inclusion (DEI) Committee is dedicated to fostering an educational and research environment that is more equitable, diverse, and inclusive for faculty, staff, researchers, enrolled, prospective and former students, and visitors.

Continued on Page 4

Faculty Focus: Meet Ching-Yao Lai

In January 2021, the AOS Program welcomed new faculty member Ching-Yao Lai, assistant professor of geosciences. We speak to Yao about her background, research, and the collaborations she hopes to forge at Princeton.

Continued on Page 8

Welcome!

One year since our worlds were rocked by a global pandemic, there are still a lot of unknowns about our return to campus and in-person teaching and research. However, we do believe things are looking up and hope that we will have a better sense of what lies ahead as we approach the summer months. We thank you once again for pressing on with your academic endeavors and for your extraordinary commitment.

In this issue, we share news of Stellar, the AOS DEI Committee and their ongoing efforts, CIMES Task III awards, and Summer Intern Rebecca Monge being named a Regeneron Science Talent Search Finalist. Congratulations to Graduate Student Yi Zhang whose research was featured in the *NYT*. A faculty Q&A with Yao Lai and research/outreach highlights round out this edition. We welcome all of our AOS/ CIMES newcomers!

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

Inside This Issue

Stellar.....	1
AOS Committed to DEI.....	1
Meet Ching-Yao Lai.....	1
World’s Most Influential Scholars.....	3
CIMES Awards.....	5
New Paper: A Timely Topic.....	9
Intern Rebecca Monge.....	10
New Research Chenggong Wang.....	11
New Research Yi Zhang.....	12
MCB&GC STEM Workshop.....	13
GFDL/Vulcan Workshops.....	14
Postponed: PDC 2021.....	14
Alumni/AOS & CIMES News.....	15

Stellar continued from Page 1

“These new high-performance computing (HPC) capabilities are vitally important to building a strong framework to support the cooperative institute’s research agenda; we are thrilled to have this computing capacity at our fingertips,” said CIMES Director Gabriel Vecchi. “Stellar is not only an important step in meeting the broad computational needs of our researchers, but also in strengthening and facilitating the long-lasting scientific partnership between the University and GFDL.”



Photo Credit: Kevin Abbey, PICSciE systems administrator

The CIMES portion of Stellar consists of 24000 AMD 7H12 cores, and is capable of running an estimated 36000 simulated years of GFDL’s publicly available flagship models GFDL-CM4 or ESM4 in one year. It has 4 PB of disk storage as well as 100 TB of high-speed “flash” storage, with an attached analysis cluster. The supercomputer will be shared with other Princeton research divisions, including the Department of Astrophysical Sciences and the Princeton Plasma Physics Laboratory (PPPL).

“With Stellar, we can expect a total throughput of 100 simulated years per day (SYPD) – a significant boost to the capabilities of CIMES researchers to design and run simulations in furthering the CIMES mission,” said AOS Senior Professional Specialist V. Balaji, who heads the Modeling Systems Group at NOAA’s Geophysical Fluid Dynamics Laboratory (GFDL). “The CMIP6 DECK suite of standard climate experiments, for reference, is about 1500 SY. We could therefore run 24 such suites in a year, with different physical configurations of the model to explore its sensitivity to model formulation.”

The supercomputer has the potential for transforming computational research at CIMES and GFDL – from performing intensive computation and modeling, to storing model output and observational data, to analyzing model output and observations, and developing alternative model configurations, all at incredible computing speeds, according to Balaji. The platform will also contain a public data portal for GFDL and CIMES data approved for public access and a

platform aimed at educating and training Princeton students in the use of Earth system models.

Curt Hillegas, associate CIO, Research Computing, Office of Information Technology and the Princeton Institute for Computational Science and Engineering (PICSciE) who was instrumental in the effort to bring Stellar to campus, said “Stellar will be the largest computational system the University has acquired and operated so far, and it represents a big step forward in technical scale and complexity.”

“More importantly, it solidifies the long collaboration between Princeton University, the NOAA Geophysical Fluid Dynamics Laboratory, and the DOE Princeton Plasma Physics Laboratory,” Hillegas said. “This scale of system coupled with the broad range of science it will serve is an incredible platform for fostering research collaboration across the three institutions and many disciplines.”

“Stellar is a win-win in the University-GFDL partnership and a game-changer for CIMES researchers in terms of accessibility, said Stephan Fueglistaler, CIMES Deputy Director. “It opens new research and collaborative possibilities under the CIMES umbrella.”

The project follows decades of Earth system and model development at GFDL and improvements made to NOAA’s research supercomputing capability.

“Stellar will open a new dimension in collaborative research between GFDL and Princeton by providing Princeton the ability to take advantage of the high-risk, high-reward exploration of academic research, including theoretical, idealized, and paleo-systems pursuits to broaden and deepen fundamental understanding of Earth system science, vulnerabilities, and opportunities towards informing GFDL’s next generation applications to NOAA’s mission,” said John Dunne, a GFDL research oceanographer.

“The Stellar HPC cluster will provide critical support to our faculty and researchers, as we build a culture of multi-disciplinary collaborations across the University and with GFDL, while significantly advancing resources for CIMES research and educational activities,” said Sonya Legg, CIMES Associate Director. “Continued access to high-performance computing is vital to our mission of attracting talented faculty, postdocs, and students through the AOS Program.”

The new high-performance computing cluster will

Stellar continued from Page 2

bolster research across a wide range of disciplines from atmospheric and oceanic sciences, climate science and extreme weather events to fluid dynamics, hydrology, and environmental policy.

“In numerical simulations of the turbulent flow in the lower atmosphere, the ability to span the big scale gap between the smallest turbulent eddies and the largest flow modes is critical for accurate results that mimic the real geophysical systems,” said CIMES principal investigator Elie Bou-Zeid, professor of civil and environmental engineering. “Stellar will provide Princeton/NOAA scientists with a unique ability to perform such simulations, with applications to urban flows, renewable energy, and weather.”

“The Stellar cluster opens many doors for our work to bridge weather and climate,” said Lucas Harris, a GFDL physical scientist. “It gives us a way to bring our advanced prediction models to the greater Princeton community. It also promises to accelerate the development and deployment of our super-huge global cloud-resolving model, advance into the new realm of weeks-to-months prediction, and push towards hyper-local modeling for stakeholders in the Greater New Jersey area.”

“Stellar will accelerate joint efforts by Princeton and GFDL to develop high-resolution coastal ocean predictions essential for understanding and anticipating marine resource responses to climate variability and change,” said Charles Stock, a GFDL research oceanographer. “Such information is crucial for ensuring resilient coastal economies, while also meeting conservation goals.”

Stellar will also play an important role in CIMES’ efforts to build new partnerships between the University and external collaborators, advancing the potential for scientific discovery beyond the Princeton campus.

This initiative, due to be operational later this year, will bring the University and GFDL, along with their shared missions, together in unprecedented ways and further the over five-decade partnership between the two, while opening new pathways for collaboration with other institutions.

The Stellar HPC cluster is the result of a collaborative effort on the part of administrators and researchers from CIMES, NOAA/GFDL, and PICSciE.



AOS Scientists among World’s Most Influential Scholars

Five AOS scientists were recognized on the Web of Science Group’s 2020 list of “[Highly Cited Researchers](#).” This index identifies global research scientists and social scientists 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 2009-2019 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), Larry Horowitz (GFDL), and CIMES Director Gabriel Vecchi, professor of geosciences and the Princeton Environmental Institute are listed for Geosciences; Jorge Sarmiento, the George J. Magee Professor of Geoscience and Geological Engineering, Emeritus is named for “cross-field” impact, reflecting his highly cited publications that span across multiple scientific fields.

Princeton University was well represented, with 33 University researchers listed among the approximately 6,400 world’s most influential scholars.

CIMES Awards \$570,000 in Earth System Sciences

The Cooperative Institute for Modeling the Earth System (CIMES) has announced awards totaling \$570,000 to support eight 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 2021 to 2022 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, we expect to collaborate closely with Paul Ginoux, Larry Horowitz and Fabien Paulot at GFDL.

Dynamic Elemental Stoichiometry in COBALT

Single-celled organisms called phytoplankton absorb sunlight, carbon dioxide, and other nutrients in the ocean's surface and eventually transfer them deep below the surface. This carbon pump strongly influences our atmosphere, climate, and the ocean environment by altering the distribution of carbon, oxygen, and nutrients throughout oceans. In this project, a team of interdisciplinary researchers led by George Hagstrom, associate research scholar in ecology and evolutionary biology, aims to better understand the controls on the carbon pump by modelling how the ratios of carbon:nitrogen:phosphorus in phytoplankton vary with environmental and ecological conditions. Usually modelled as constant, recent laboratory and field data suggests that phytoplankton vary their nutrient ratios in response to the environment, becoming extremely efficient at using phosphorus when nutrients are scarce. By capturing dynamic stoichiometry in GFDL's global ocean models, the researchers, including GFDL Research Oceanographers Charles Stock and Jessica Luo and Simon Levin, the James S. McDonnell Distinguished University Professor in Ecology and Evolutionary Biology, will improve their understanding of carbon export in the current ocean and also better predict how marine ecosystems respond to human-caused environmental changes such as pollution or climate change, enabling society to better plan for the future.

Continued on Page 6

Validating, Improving, and Assessing Marine Nitrification under Climate Change in GFDL's Earth System Model 4 (ESM4)

Nitrification, the microbially mediated oxidation of ammonium to nitrate, controls the availability of different forms of nitrogen to support primary production. It also results in the formation of nitrous oxide, a potent greenhouse gas. In this project, Bess Ward, the William J. Sinclair Professor of Geosciences and the High Meadows Environmental Institute, and a team of researchers, including Weiyi Tang, a postdoctoral research associate in Geosciences, will assess the sensitivity of marine nitrification to climate/anthropogenic change including warming, ocean acidification and increasing N deposition. The researchers have developed a database of nitrification rate measurements, and have parameterized the relationship among reaction rates and environmental variables. New parameterizations and machine learning methods will be used to improve the representation of nitrification in global models in order to improve models and predictions of the response of marine productivity to ecosystem stress and climate change.

A Statistical Perspective of the Tropical Circulation – Theory and Empirical Support

Tropical deep convection is observed to be organized on a range of spatial and temporal scales. In this project, Stephan Fueglistaler, associate professor of geosciences, and AOS Graduate Student Yi Zhang explore alternatives to the traditional geographic perspective to describe and understand the organization of tropical deep convection. Published results from this project include a theoretical argument why tropical rainfall distribution is expected to become (even) less evenly distributed under global warming (Zhang and Fueglistaler, GRL, 2019), and empirical proof in observations and model simulations (Zhang and Fueglistaler, GRL, 2020) that the subcloud moist static energy in regions of tropical deep convection is equal over land and ocean in all climates (ranging from past cold glacial to future warm climates). These results have important implications for heat stress at low latitudes (Zhang et al. 2021).

References:

1. Zhang, Y., S. Fueglistaler, Mechanism for Increasing Tropical Rainfall Unevenness with Global Warming, *Geophys. Res. Letts.*, 46, 14,836–14,843, doi.org/10.1029/2019GL086058, 2019.
2. Zhang, Y., S. Fueglistaler, How tropical convection couples high moist static energy over land and ocean, *Geophys. Res. Letts.*, 47 (2), e2019GL086387, doi:10.1029/2019GL086387, 2020.
3. Zhang, Y., Held, I. & Fueglistaler, S. Projections of tropical heat stress constrained by atmospheric dynamics. *Nat. Geosci.* 14, 133–137 (2021). <https://doi.org/10.1038/s41561-021-00695-3>.

Evaluating the Biological Carbon Pump in a Water Mass Framework

The ocean's "biological pump" is a mechanism by which organic matter, which grows in the sunlit surface waters, is transported to the deep ocean. By moving carbon away from the surface, the process plays a crucial role in mediating levels of atmospheric pCO₂ on timescales from decades to millennia. This project is about putting a novel spin on our framing of the biological pump, to assist in quantifying its magnitude and understanding its dynamics. In this project, Graeme MacGilchrist, an AOS postdoctoral research associate, and collaborators AOS Faculty Member Steve Griffies, a GFDL physical scientist, John Dunne, a GFDL research oceanographer, GFDL Physical Scientist John Krasting, and Jorge Sarmiento, the George J. Magee Professor of Geoscience and Geological Engineering, Emeritus, will analyze GFDL's Earth System Models (ESMs) in a framework that considers the ocean as a stack of moveable layers through which we can accurately quantify the movement of organic matter. The novel approach is hypothesized to help constrain our understanding of this critical process and improve its representation in ESMs, ultimately improving centennial-timescale climate projections.

Continued on Page 7

CIMES Awards continued from Page 6



Extreme Rainfall and Flooding the Lower Mississippi River Basin

One of the most consequential issues concerning climate change impacts on flooding in the US is whether extreme floods in the Lower Mississippi River 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? Can state-of-the-art Earth System Models accurately represent rainfall variability at time and space scales associated with major Lower Mississippi River flood episodes? What are the principal climate drivers of extreme rainfall in the Lower Mississippi River? Are extreme floods in the Lower Mississippi River increasing in frequency? A core objective of this project is assessing and enhancing the capabilities of Earth System Models developed by GFDL to simulate extreme convective rainfall.

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 increase¹, 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, Columbia University, 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 enabled².

Team Members:

Sirisha Kalidindi, Princeton Department of Geosciences; Gabriel Vecchi, Princeton Department of Geosciences and High Meadows Environmental Institute; 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, Columbia University; 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.
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>.

Ching-Yao Lai continued from Page 1

Faculty Focus: Meet Ching-Yao Lai



What is your educational background?

I earned an undergraduate degree in Physics at National Taiwan University. I have been fascinated by how we can use mathematical models to describe the world. I am interested in coming up with the simplest possible way to understanding the complexity in nature. I did my Ph.D. with Dr. Howard Stone in fluid dynamics in the mechanical and aerospace engineering department at Princeton. My Ph.D. research focused on fundamental problems related to the interaction between elasticity and viscous flows, with applications in geophysics. Although I was in the engineering department, the collaborative atmosphere in Howard's group with scholars in other disciplines had a deep influence on me. Princeton has provided enormous resources to bring together interdisciplinary scholars interested in environmental sciences. In particular, ACEE and PEI (now HMEI) have played important roles in broadening the scope of my thinking. This is why I am thrilled to be back and be part of this collaborative environment.

What is your area of research/expertise?

I study the mechanics of ice, and more generally, the poorly understood processes that govern the future of ice dynamics. The flow of ice sheets is sensitive to the changing climate. For example, meltwater at the surface of the ice sheet can crack through the ice thickness (~1km) and lubricate the bottom of the ice sheet in contact with the bedrock. This meltwater lubrication can cause the ice sheet to slip. Meltwater also can lead to the disintegration of ice shelves due to hydrofracture. In my group, we develop mathematical models and compare it with observations. More recently, due to the increase amount of observational

data, I have been interested in leveraging the recent advance in deep learning techniques to scale up data-model comparisons.

What inspired you to pursue an academic career in your discipline?

Ice dynamics and the future ice loss of ice sheets is one of the most pressing problems that need to be solved to predict future changes in sea level. Ice flows as a fluid and breaks as a solid, so modeling of ice dynamics involves expertise in both solid and fluid mechanics; this is where my background fits in. In addition to modeling ice dynamics, I am very interested in the broader scope of topics it involves, such as its interactions with the ocean and atmosphere, and its connections with global sea-level rise.

Regarding a career in academia, it is my dream to do research. I have met many mentors in academia who have had a profound impact on my career. Mentorships are important because they can have a powerful impact on someone's life. I also enjoy having a community where people's end goal is to promote science and where there are many intelligent minds working toward that goal. It is amazing people can get very excited about each other because of their research and ideas, even before they get to know each other. Science is like another language to express oneself and enhance the connection between individuals. Overall, I really enjoy research and being in a supportive and stimulating academic environment.

Do you see opportunities for new, collaborative research, given the breadth and depth of research conducted at the University?

Absolutely. I am excited about developing collaborations with faculty members in Geosciences, AOS, GFDL, HMEI, and MAE who are interested in climate science, fluid dynamics, and machine learning. For my research, in addition to developing a deeper understanding of ice-sheet processes, it is important to translate the process-level understanding to larger-scale questions, such as the ice loss of ice sheets and its contribution to rising sea levels. Princeton AOS is unique because the students/faculty members can talk to GFDL scientists from a broad range of expertise in climate modeling. This is one of the factors that drew me back to Princeton.

Continued on Page 9

Ching-Yao Lai continued from Page 8

I also benefit a lot from hearing about the research from other groups across different departments. The HMEI and ACEE seminar series are a good place to meet researchers from different areas with similar interests in environmental sciences.

What are you most excited about during your first year with the Program?

Without COVID, I would be most excited about meeting students and faculty members and hanging out at different events. It is difficult now that casual meetings and chats do not occur naturally. That said, it is really nice to have the online social hours, and I cannot wait to participate in in-person social events. Another thing I am very excited about at this moment is welcoming the incoming prospective students.

What do you enjoy doing when you are not working?

I really like the beauty in nature. In autumn and spring, I enjoy camping and hiking with friends. I also am very into photography. In fact, my fascination with ice is probably simply because it is enjoyable to see the beautiful observational pictures.

Favorite piece of advice from a mentor or inspiring figure in your life?

“Don’t box yourself in. Ignore labels and boundaries.” After my Ph.D., I thought about continuing research in fundamental fluid dynamics for my postdoc research. At the same time, I was extremely curious about exploring research in other fields, especially in climate science. The world is changing fast, and it is now easier to access knowledge in another field and ask new research questions from a different perspective. The transition was initially difficult. It is normal to feel the previous training was wasted when your future goals deviate from your initial plan. It is also easy to attribute any initial failures to the transition. It was my Ph.D. advisor who told me my next step doesn’t have to be in the same field as my Ph.D. degree. He pointed out many successful examples where people’s Ph.D. degrees are different from the department where they finally end up. The degree name is just a label and it should not limit what you do afterwards. Furthermore, I am very thankful for a few mentors at AOS and GFDL who showed warm encouragement for my plan to make a transition. It was a big relief to know that it is okay to make changes. My previous training was not wasted; instead, it actually helped bring some fresh thinking to my current field.

A Timely Topic: Adherence to Health Precautions, Not Climate, the Biggest Factor Driving Wintertime COVID-19 Outbreaks

Wintertime outbreaks of COVID-19 have been largely driven by whether people adhere to control measures such as mask wearing and social distancing, according to a study published Feb. 8 in *Nature Communications* by Princeton University researchers. Climate and population immunity are playing smaller roles during the current pandemic phase of the virus, the researchers found.

The researchers — working in summer 2020 — ran simulations of a wintertime coronavirus outbreak in New York City to identify key factors that would allow the virus to proliferate. They found that relaxing control measures in the summer months led to an outbreak in the winter regardless of climate factors.

“Our results implied that lax control measures — and likely fatigue with complying with control measures — would fuel wintertime outbreaks,” said first author Rachel Baker, an associate research scholar in Princeton’s High Meadows Environmental Institute (HMEI). Baker and her co-authors are all affiliated with the HMEI Climate Change and Infectious Disease initiative.

In May, the same authors published a paper in the journal *Science* suggesting that local climate variations would be unlikely to affect the coronavirus pandemic. The paper suggested that hopes that the warmer conditions of summer would slow the transmission of the novel coronavirus, SARS-CoV-2, in the northern hemisphere were unrealistic.

CIMES Director Gabriel Vecchi, a professor of geosciences and the High Meadows Environmental Institute and co-author of both studies, said that the virus currently spreads too quickly and that people are too susceptible for climate to be a determining factor.

“The influence of climate and weather on infection rates should become more evident — and thus a potentially useful source of information for disease prediction — as growing immunity moves the disease into endemic phases from the present epidemic stage,” Vecchi said.

Read more on the [University homepage](#).

Intern Rebecca Monge Named Finalist in Regeneron Science Talent Search 2021

Congratulations to Intern Rebecca Monge, who was named a top 40 Regeneron Science Talent Search finalist. Regeneron Science Talent Search Society for Science is the nation's oldest and most prestigious science and math competition for high



school seniors. Monge conducted her research as a Carmel High School rising senior with AOS Professional Specialist Aparna Radhakrishnan and Lori Sentman, a GFDL physical scientist, this past summer.

The 2021 finalists were selected from 1,760 highly qualified entrants, all of whom completed an original research project and extensive application process. Monge identified specific zonal influencers on polar amplification (PA), a key driver of climate change for her Regeneron Science Talent Search Earth and planetary sciences project.

PA, the accelerated rate of warming at higher latitudes, threatens the natural planetary cooling system of the Arctic. To better understand the relative roles of temperature, snow cover, heat fluxes and other factors that influence PA, Monge analyzed scores of data from the most recent and comprehensive climate models available. She then plotted zonal maps that highlighted geographical drivers and components of PA, specifically temperature and heat flux increases surrounding Norway and reduced snow cover in upper Greenland. Her findings suggest targeted regional mitigation may be an especially effective strategy to lessen Arctic warming.

In early January, the Society and Regeneron named Monge a top 300 scholar, based on her projects' scientific rigor and her potential to become a world-changing scientist and leader. Now as a top 40 finalist, Monge will participate in a virtual competition from March 10-17, 2021, where she will undergo a rigorous virtual judging process and join fellow finalists competing for more than \$1.8 million in awards. The finalists are each awarded at least \$25,000, and the top 10 awards range from \$40,000 to \$250,000.

The finalists will also have an opportunity to interact with leading scientists and display their projects to the public

during a virtual event on March 14. Typically held in person in Washington, D.C., the 2021 competition will take place virtually due to the pandemic.

The top 10 Regeneron Science Talent Search 2021 winners will be announced during a live-streamed virtual awards ceremony on March 17. In total, more than \$3 million in awards will be distributed throughout the Regeneron Science Talent Search, which includes awards to finalists as well as \$2,000 provided to each of the top 300 scholars and their schools.

In addition to her scientific endeavors, Monge is a varsity distance runner and member of the mock trial club, winners of the 2020 Putnam County tournament. She co-founded and co-directs the Copula Program, matching academic mentors with high school students, and co-directs and teaches the Putnam County English as a Second Language program.

"Rebecca's hard work and day-to-day efforts have paved the way to the Regeneron finals," said Radhakrishnan. "She leverages her passion for STEM education and humanity to bring out the best in herself and inspire other budding researchers! Rebecca truly is an outstanding young researcher and a wonderful person to interact with."

"Rebecca's thirst for knowledge and ability to assimilate new ideas efficiently is highly commendable, and her ambitious, go-getter attitude really shines!" said Sentman. "She has consistently demonstrated versatility, resourcefulness, and confidence when facing various challenges along the way. It has been a pleasure to mentor her and watch her grow over the past few years. I have no doubt she will succeed and thrive in future endeavors,"

Each year, approximately 2,000 student entrants submit original research in critically important scientific fields of study and are judged by leading experts in their fields. Unique among high school competitions in the U.S. and around the world, the Regeneron Science Talent Search focuses on identifying the next generation of scientists and engineers who will provide critical leadership in solving some of the world's most pressing challenges while shaping the future of research and development for our nation and the world.

Program alumni include recipients of the world's most coveted science and math honors, including 13 Nobel Prizes, 13 National Medals of Science, six Breakthrough Prizes, 21 MacArthur Foundation Fellowships and two Fields Medals.

High End of Climate Sensitivity in New Climate Models Seen as Less Plausible



Understanding how clouds modulate climate change sits at the heart of climate research. Clouds can amplify global warming and may cause warming to accelerate rapidly during the next century.

New research, led by AOS Graduate Student Chenggong Wang, explores the latest generation of climate models, some of which have a climate sensitivity that far exceeds past model estimates, and examines what is behind the large inter-model spread of climate sensitivity.

Climate sensitivity refers to the amount of global surface warming that will occur in response to a doubling of atmospheric CO₂ concentrations compared to pre-industrial levels. The wide range of estimates of climate sensitivity is driven by uncertainties in climate feedbacks, including how clouds and other factors will change as the Earth warms.

The response of clouds to surface temperature change can amplify or dampen the greenhouse gas induced warming, also known as cloud feedback. The study shows that cloud feedback is the leading driver of spread in model-based estimates of climate sensitivity. The researchers report in the journal *Geophysical Research Letters* that in the latest generation of climate models, those models with a more positive cloud feedback tend to have a stronger cooling effect from aerosol cloud interaction.

“We find that even though these new models have a climate sensitivity that ranges from less than 2°C to almost 6°C, the spread due to differences in the way clouds respond to warming, all show global warming over the historical record that is similar to observations,” said co-author Gabe Vecchi, director of CIMES.

The researchers also found that the agreement over the historical period in global-mean warming is due to the models with high sensitivity of warming to CO₂ also having a very large sensitivity of clouds to aerosol changes, which leads to compensation between historical CO₂ warming and aerosol cooling.

“Our analysis shows that both the high and low climate sensitivity models can simulate the global temperatures observed in the 20th Century, since the higher climate sensitivity models also tend to have a stronger cooling effect from aerosol-cloud interaction that offsets the greater warming due to greenhouse gases,” said Wang. “However, because the aerosol emissions primarily occur in the Northern Hemisphere, those higher climate sensitivity models show unreasonable cooling in the Northern Hemisphere compared to the Southern Hemisphere in the second half of the 20th century, which is not consistent with observations.”

“Improving our understanding and ability to correctly simulate clouds is really the key to more reliable predictions of the future,” Wang said. “There is still much we can learn, however, from observations in the past – such as the interhemispheric pattern of temperature change – that can help refine the interpretations we get from global mean temperature change.”

These findings can help researchers better understand and reduce the uncertainty in the projected future warming and inform critical carbon mitigation strategies and climate policy.

Additional authors on the paper include Brian Soden, a professor of atmospheric sciences at the University of Miami’s Rosenstiel School of Marine and Atmospheric Science, and Wenchang Yang, an associate research scholar in geosciences at Princeton.

The study, “[Compensation between Cloud Feedback and Aerosol Cloud Interaction in CMIP6 Models](#),” was published February 28 by the journal *Geophysical Research Letters*. The work was supported in part by NOAA and the Carbon Mitigation Initiative at Princeton University.

Projections of Tropical Heat Stress Constrained by Atmospheric Dynamics



Image credit: NYT/Hotli Simanjuntak/EPA, via Shutterstock

Congratulations to AOS Graduate Student [Yi Zhang](#), a CIMES researcher, whose [paper](#) published online March 8 in *Nature Geoscience* has been featured in the *New York Times*, *The Guardian* and other media. Together with AOS Senior Meteorologist [Isaac Held](#) and AOS Director [Stephan Fueglistaler](#), Yi Zhang addresses the problem of heat stress in the tropics in a warming world.

Humans' ability to regulate body heat is dependent on the temperature and humidity of the surrounding air, and heat stress will occur when it is too hot and humid. There exists an upper survival limit, beyond which humans are no longer able to effectively cool themselves. This threshold is reached when the wet-bulb temperature — a measure of air temperature and humidity — passes 35 °C. There is concern that ongoing climate warming could result in extreme heat events that exceed this limit.

Yi Zhang and co-authors find that relatively [simple atmospheric dynamics](#) control the maximum wet-bulb temperatures in the tropical regions between 20°S and 20°N. A combination of theory, observations, and global climate models points to the conclusion that the annual-maximum wet-bulb temperature will increase uniformly by 1°C for each 1°C of tropical mean warming. These findings suggest that limiting global warming to 1.5 °C could prevent tropical regions between 20°S and 20°N of the equator from reaching the limit of human adaptability. However, the authors indicate further research will be needed as serious health impacts can still occur well below this limit.

[New York Times article](#)

Inspiring Youth at Boys & Girls Clubs of Mercer County Annual Stem Conference

On Thursday, November 5, 2020, the Boys & Girls Clubs of Mercer County hosted its annual youth STEM conference for students between fifth and ninth grades. Oceanography, robotics, health science, material science, computing, and network engineering represented some of the 17-themed workshop areas and career panels intended to spark youth interest in science, technology, engineering, and math.

CIMES Associate Director Sonya Legg, an AOS faculty member, was among the enthusiastic volunteers on hand, from local universities, organizations and companies, to serve as exhibitors and lead STEM activities.

On the day of the workshop, Legg conducted three consecutive live “kitchen oceanography” workshops of 45 minutes each, each with three to six middle-school aged participants joining from either their own homes or the MCB&GC Center in Lawrence, New Jersey. The in-person option is essential for MCB&GC members, many of whom do not have internet access at home.

A week prior to the conference, kits containing materials and instructions were distributed to the workshop participants so they could immerse themselves in eight hands-on experiments, during the live sessions, under Legg’s guidance. The kits were composed of plastic containers holding common kitchen ingredients such as salt, oil, and food coloring and students only had to add water. The experiments included vortex swirl, gravity current, internal wave, wind-driven waves, mixing and stirring, surface wave resonances and tsunami, oil and water, and oil spill, according to Legg.

The live format enabled the students to seek help from Legg when needed, and respond to questions from Legg intended to encourage them to think like scientists and extend their understanding of oceanography.

“The MCB&GC STEM workshop is a fantastic event for bringing science to students from our local Mercer county community who may otherwise have little exposure to fields such as oceanography, and I’m very glad they decided to continue their annual event in virtual mode,” Legg said. “Hands-on activities make learning

much more fun, so while I was a bit worried about the potential for accidents involving computers and water, the responses such as ‘Ooh, that’s so cool’ made the effort worth it!”

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 the local community.



Workshops Explore Efforts to Blend New Technologies into GFDL Models

GFDL collaborated with Vulcan Inc. to host two workshops, attended by GFDL and AOS/CIMES researchers and students, on their efforts to blend new technologies into GFDL models. The first, held in November 2020, focused on Domain Specific Languages for the FV3 dynamical core.

A domain-specific language (DSL) is a programming language with concepts tailored to a specific class of problems. By sacrificing generality, DSLs can strike a better balance of performance, portability, and performance.

The goal of the workshop was to learn what DSL can and cannot do; to understand how a DSL helps in writing hardware-agnostic, maintainable code without sacrificing performance; and to experience an interactive, Python-based development environment on a supercomputer for model development, according to GFDL Physical Scientist Lucas Harris, a co-organizer of the workshop and former AOS postdoc.

The second workshop, held in January 2021 and co-organized by AOS alumnus Spencer Clark, a software engineer for climate model development at Vulcan, explored a Python wrapper for the FV3GFS weather model, allowing considerably more flexibility in running GFDL models than the current Fortran codes, said Harris. "It will allow the model to be easily ported between computing platforms, from large supercomputers down to personal laptops. It will also improve instrumentation, debugging, and understanding of the model by making it easier for users to plug in their own scripts deep within the model to see what it is doing at any particular time," he said.

Similarly, users can rapidly prototype and test out new capabilities in the code by writing a Python code and calling it from the wrapper. "Anything within the wrapper can also take advantage of the universe of Python libraries, from advanced graphics to cutting-edge machine learning tools, greatly extending what can be done with the GFDL modeling system," said Harris.

The workshops brought in a total of 40 scientists, engineers, and students from the AOS/GFDL community, and from the Department of Energy, NASA, and the National Weather Service. AOS researchers participating in the DSL workshop included AOS Postdocs Kai Cheng and Yongqiang Sun, AOS Research Software Engineer Joseph Mouallem, and AOS Senior Professional Specialist V. Balaji, who heads the Modeling Systems Group at GFDL. Cheng and Mouallem also participated in the Python wrapper workshop, as did AOS Postdocs Kun Gao, Suqin Duan, and Naser Mahfouz and GEO Associate Research Scholar Wenchang Yang.

The workshops were an outgrowth of a partnership between GFDL and Vulcan that ensures that Vulcan's efforts to create open-source and collaborative solutions in climate modeling builds on GFDL's deep expertise in numerical climate modeling, development, and research as well as its computing resources.

POSTPONED: PDC 2021

In light of the ongoing concerns and public safety and health restrictions associated with COVID-19, the Physics-Dynamics Coupling Workshop Organizing Committee has postponed the planned PDC 2021 workshop until the summer of 2022. The committee is hoping that the meeting can safely take place in-person next year.

Co-sponsored by CIMES and GFDL, the workshop would have been the fourth in a series of biannual workshops aimed at bringing together the growing community of scientists who have an interest in discussing and improving process coupling in geophysical modeling.

"We have used the postponement as an opportunity to deconstruct the traditional scientific workshop concept for our era of maximum telework," said GFDL Research Scientist Lucas Harris, a former AOS postdoc

and member of the 2021 organizing committee. The committee has come up with the idea of a virtual "PDC Discussion Coffee" to be held the week of June 8, 2021. This will include a couple of 90-minute sessions (60 minutes of talks and 30 minutes of discussion) with lightning talks no longer than two slides and five minutes, according to Harris.

"Our hope is that this will be a low-barrier way for a lot of people to quickly present some new results without the drag of a full multi-day conference that might need to span many time zones," Harris said.

In addition to more seasoned researchers, those new to the field – early-career scientists interested in model development, in particular – are encouraged to participate. Details on registration and abstract submission can be found at: <https://pdc-workshop-abstracts.com/event/3/>.

Alumni News

GFDL Physical Scientist, **Lucas Harris**, a former AOS postdoc, won a Department of Commerce Group Gold Medal “for the development and accelerated implementation of NOAA’s flagship Global Forecast System GFSv15.1, a foundation for FV3 based Unified Forecast System.”

“Drivers of subsurface temperature variability in the Northern California Current,” a paper led by former AOS Associate Research Scholar **Sulagna Ray** (EMC/NCEP/NOAA) was PMEL’s [featured publication](#) in February.

AOS & CIMES News

AOS Faculty Member **Stephen Griffies**, a GFDL senior scientist, is the new editor-in-chief at the AGU journal JAMES, effective January 1, 2021. [Eos Announcement](#)



AOS Postdoc **Hyung-Gyu Lim** won an Outstanding Ph.D. Thesis Award from the Korean Society of Oceanography (2020), based on his [paper](#), “Biogeophysical feedback of phytoplankton on the Arctic climate. Part I: Impact of nonlinear rectification of interactive chlorophyll variability in the present-day climate.”

Arrivals

Karina Castillo joined the Program in mid-December as our new grants manager. She comes to us from Mechanical and Aerospace Engineering here at Princeton.

Cristina Schultz joined us in early January, from the University of Virginia, to work with John Dunne as a postdoc.

Gregor Havkin joined us in early February as the Program’s new SCAD (Support for Computing in Academic Departments).

Departures

AOS Postdoc **Neeraja Bhamidipati** left the Program in mid-January. She accepted a quantitative researcher position at GSA Capital in London.

AOS Associate Research Scholar **Xi Chen** left the Program in early March. He accepted a scientist position at the Institute of Atmospheric Sciences of the Chinese Academy of Sciences.

University Updates!

Check out the most recent [spring term 2021 graduate students announcements](#).

Visit the [COVID-19 website](#) for more information about the University’s [travel policy](#).

