

GPC Newsletter

Issue #22

October 2025

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Message from the Editor

This is the twenty-second GPC Newsletter, normally published twice per year. You, the GPC membership, can be of enormous value. We invite comments, event notices, letters, and especially specific suggestions for content. Any of the above, addressed to GPCnews@aps.org, will be gratefully acknowledged in a timely fashion.

Message from the GPC Chair

Geoffrey Vallis, University of Exeter

We are most of the way through one of the most tumultuous years that we have seen in the area of climate science. Global warming continues apace, and [NOAA reports](#) that 2024 was the warmest year since records began. The global average surface temperature was 1.3 degrees Celsius above the 20th-century average, and almost 1.5 degrees Celsius above the pre-industrial

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2026 APS Global Physics Summit

The 2026 joint March and April Meetings, known as the [APS Global Physics Summit](#), will take place in Denver, CO March 15-20. GPC is planning one Symposium, three Focus Sessions ("Observations and Data Assimilation," "Radiation, Clouds and Microphysics," and "AI Applications to Climate"), and possibly one or more Standard Sessions – depending on the quantity of contributed abstracts received. Desired topics for the latter include "Solar Radiation Management and Geoengineering," "Climate Physics Education," "Atmosphere, Ocean and Climate Dynamics," "Statistical and Nonlinear Physics of Earth and Climate," "Cryospheric Physics," "General Weather and Climate Physics," "Extreme Events, Tipping Points, and Abrupt Changes in the Climate System").

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ARTICLE: Confirming a critical foundation of global warming: Direct observational evidence from space of the effect of CO₂ increase on infrared spectral radiances

João Teixeira, Robert C. Wilson, Heidar T. Thrastarson; Jet Propulsion Laboratory

For the first time, the detailed impact of the increase of atmospheric carbon dioxide (CO₂) in reducing Earth's ability to emit infrared radiation, a key driver of global warming, has been directly measured from space. Using data from the Atmospheric Infrared Sounder (AIRS) on the Aqua spacecraft, a new method was developed to isolate the impact of CO₂ on outgoing infrared

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APS Report: Removing carbon dioxide from the atmosphere to stop climate change: Can it really be done?

Brad Marston, Brown University

The dire consequences of our continued burning of fossil fuels — oil, coal, and natural gas — are now obvious to anyone paying attention. We are failing to switch quickly enough to renewable energy sources to slow climate change.

Many start-up companies are seeking a solution through the removal of carbon dioxide from Earth's atmosphere. But can this really work? Basic physics tells us it will be difficult.

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Message from the GPC Chair – *continued from p. 1*

average (namely the period from 1850-1900). The irony, if one may use such a gentle word in these circumstances, is that NOAA – the main US government agency devoted to weather and climate matters, with a mission to ‘understand and predict changes in climate, weather, ocean and coasts’ – is under severe budgetary threats, with the very real possibility that NOAA research, especially in climate-related matters, will be severely curtailed, greatly impacting some of our world-leading climate laboratories. Such budgetary cuts will not, unfortunately, prevent global warming, but they will prevent us knowing what its effects will be and how we might best mitigate those effects. So, let’s begin this article with a brief summary of what we know about climate change and what we don’t know. We’ll then discuss the role of GPC and the physics community in all this.

What we know, with certainty, is that global average surface temperature has increased almost monotonically (with some decade-or-longer hiatuses) over the last 150 years. We know also that this temperature increase is primarily due to the increased concentration of anthropogenic greenhouse gases (carbon dioxide being the main one). We know this because we can measure temperature and carbon dioxide levels quite accurately and because we understand the radiative effects of carbon dioxide. We also know that the increased carbon dioxide has anthropogenic origins because of its isotopic composition and because we know that burning fossil fuels releases carbon dioxide into the atmosphere. Anyone who denies these simple truths is either ignorant or dishonest and should be called out as such. It is true that temperature has varied significantly in the past, and has at times been significantly warmer than today (for example in the Eocene some 60 million years ago) and much cooler (for example in the ice ages, the last one being some

20,000 years ago). But never has temperature increased so rapidly as it has in the last 100 years, and we know of no natural cause that could lead to that.

We are also sure that, if we keep burning fossil fuels, temperature will keep on increasing, although we don’t know *exactly* how much the temperature will increase for a given increase in carbon dioxide levels. The climate sensitivity is commonly defined as the increase after a doubling of carbon dioxide, with the transient climate response (or transient climate response) being the shorter term (decadal-scale) response after the upper ocean has equilibrated. The equilibrium climate sensitivity is the long-term response, relevant when the deep ocean and other slow changes in the climate system have come into equilibrium. The transient climate sensitivity is the more societally relevant, and this is in the region of 2 degrees Celsius of warming for a doubling of CO₂.

But underneath these seemingly benign figures (who would object to slightly warmer climate?) lie a host of unknowns and less benign consequences. We don’t properly understand the regional consequences of such global warming, and this is determined by the patterns of storms and changes in rainfall distributions. These are affected by changes in cloudiness (both low and high) and cloud patterns, and these in turn are influenced both by the nonlinear fluid dynamics of the large-scale circulation and the complicated physics of aerosol-cloud interactions. The reader can surely add their own favorite unknowns to this list. Put simply, our climate is determined by the complicated physics of the interaction of fluid dynamics, radiation and the thermodynamics of phase changes. Some changes in climate transcend the particular complications these effects entail – global warming itself for example – but a full understanding of many of the seeming details that so affect our experience of climate – floods, droughts,

heatwaves, desertification and so on – remains elusive.

Where does GPC fit into this? Our primary role is simply *to do science*, in particular physical science, as best we can, without fear or favor. And, where needed, we can call out bad science, or the ignoring of science. We are not, as an organization, concerned with societal impacts, with two caveats to that remark. First, it is the societal impacts that motivate many of us, and that (at least in times past) have given rise to the funding for our work. Second, individual scientists are also citizens, free to and arguably with a responsibility to call out the consequences of climate and climate change to the human condition. We may not have any special expertise in social and economic matters, but we can draw attention to where and how climate and climate change affects such matters.

Physics is but one aspect of the climate system, but it is perhaps the aspect that most seeks to provide foundational understanding. Our members are a blessedly talented group of physicists, and within that group can be found specialists in fluid dynamics, in radiation, in cloud physics, in thermodynamics, in quantum mechanics, in classical mechanics – indeed in physics across the board. Our motivations may differ – some pursue the subject just out of curiosity or for fun, and some from a deep obligation to be useful to society. But I think we are united in our belief that science is an essential part of society. We currently live in troubled times, with attacks on science and the disrespect of scientific opinion. The antidote to that is to be open and communicative, to both do science and explain science. No one is good at all things, so individuals should find their own niche in this. Scientists still are respected by the general public (and let’s not forget we are part of the general public). If we can maintain and build on that respect, then we will come out of this period as strong as ever.

2026 APS Global Physics Summit – *continued from p. 1*

GPC will also be running a climate physics tutorial on Sunday, March 15, titled “Cross-disciplinary physics for understanding climate.” Speakers Pedram Hassanzadeh, (U. Chicago), Brad Marston (Brown), Yue (Olivia) Meng (Purdue), and Robin Wordsworth (Harvard) will cover new

contributions to climate science that required sophisticated applications of tools from other branches of physics, including fluid dynamics and condensed matter, quantum mechanics, AI and computing, and soft matter.

Finally, the GPC annual business meeting is tentatively planned for Monday, March 16

from 5-6 pm – to be confirmed or adjusted later by E-mail.

Contributed abstract submission deadline is October 23, 2025. It is emphasized that although abstracts consistent with the previously listed topics are certainly desired, *any climate physics related contribution will be welcomed.*

ARTICLE: Confirming a critical foundation of global warming: Direct observational evidence from space of the effect of CO₂ increase on infrared spectral radiances – continued from p. 1

radiation. These results, which align closely with theoretical predictions, provide robust experimental confirmation of this core mechanism underlying climate change.

It has been known for more than a century that an increase of atmospheric CO₂ can lead to global warming by altering the infrared (longwave) radiative fluxes of energy at the top of the Earth's atmosphere. While remarkable progress has been made in many critical aspects of the physics of climate change [1-7], the experimental confirmation from space of the direct effects of CO₂ (independent from temperature and water vapor changes) on the Earth's outgoing infrared radiation has been elusive. This is because of the sparsity of long term (and stable) high spectral resolution observations of infrared radiances before the early 21st century and the challenge of disentangling the effects of CO₂, temperature, and water vapor on the observed spectral radiances.

While measurements from space of the spectral effects of the combined changes in CO₂, temperature, water vapor and other gases have been published [8-13], the direct effects of CO₂ by itself have not been measured from space. In an important paper, Ref. [8] calculated the spectral differences between two infrared satellite instruments, launched more than twenty years apart. Despite the difficulties of accurately estimating spectral differences between such different instruments, Ref. [8] could discern and somewhat assign, using model simulations, some of the spectral differences to changes in greenhouse gases such as CO₂. However, they did not attempt to disentangle the effects due purely to CO₂ from the temperature and water vapor effects, directly from the observations. More recently, Refs. [10, 12] highlighted the remarkable stability of the AIRS spectral radiance record, but again only isolated the effects of temperature, water vapor and CO₂ using modeling approaches and did not try to disentangle the impact of CO₂ (or other gases) from temperature and water vapor in the observational data directly.

Recently, Ref. [14] proposed a new methodology (illustrated in Figure 1) for a direct measurement of the effects of CO₂

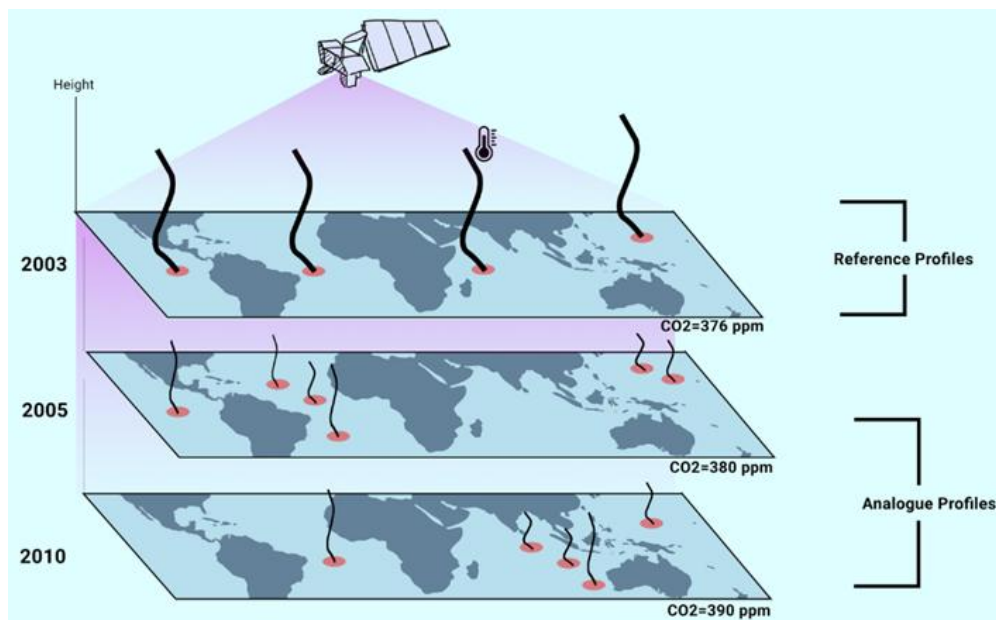


Figure 1: Schematic illustrating the new analogue methodology proposed in Ref. [14]. A set of temperature and water vapor reference profiles, measured in 2003, is selected. A search algorithm is used to find temperature and water vapor profiles that are similar to the reference profiles (referred to as analogues) but are measured over many years (2005 and 2010 are examples in the figure) which implies that they have significantly higher CO₂ concentrations, as atmospheric CO₂ is steadily increasing.

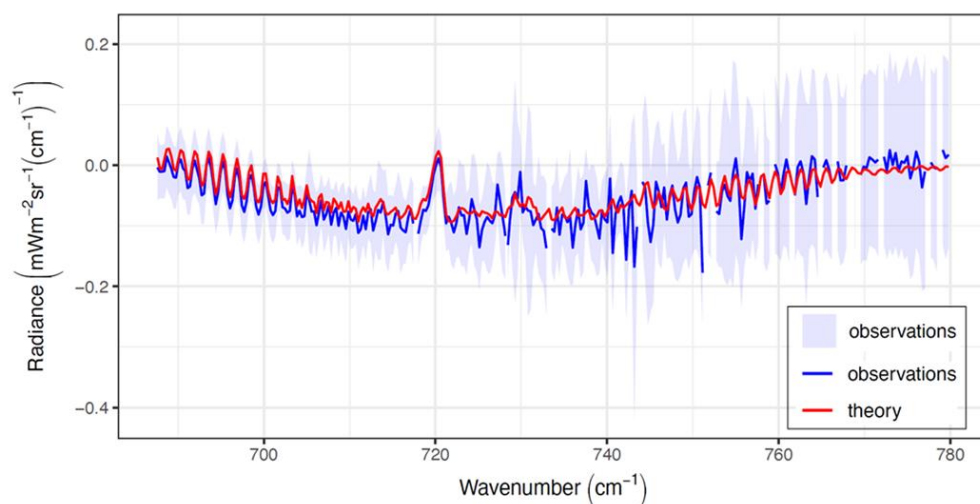


Figure 2: Annual mean radiance differences [in $\text{mWm}^{-2} \text{sr}^{-1} (\text{cm}^{-1})^{-1}$] due to CO₂ increase, from the AIRS observations (blue line) and from theory (red line), and standard deviations for the AIRS observations (blue shading), following the methodology described and illustrating the direct impact of CO₂ increase on the spectral radiances during the 2003-2012 period (from Ref. [14]). The small-scale oscillations are most likely due to noise/uncertainty associated with the analogue sampling method that is used.

increase on infrared spectral radiances to provide a more precise comparison with theory. The goal of this approach is to isolate the effects of CO₂ from the effects of temperature and water vapor in the observations. This is achieved by searching for atmospheric profiles of temperature and water vapor (referred to as analogues) that are as similar as possible to an initial set of reference profiles (from 2003 in this study) but have CO₂ concentrations that are significantly different. Measuring from space over many years (starting in 2003) the spectral radiances that correspond to

these analogues makes it possible to detect the unique impact of CO₂ on the radiances with enough precision and accuracy in key spectral regions.

The infrared spectral radiances are measured by AIRS [15] which is a hyperspectral instrument on the Aqua spacecraft covering the 3.7-15.4 μm infrared spectral region with 2378 channels. The profiles of atmospheric temperature and water vapor, as well as cloud properties, are from a combination of physical retrieval, neural network, and data

assimilation methods that use a variety of observation types [14].

To estimate the impact of CO₂ increase on the observed spectral radiances, the differences between the radiances observed at the location and time of each analogue and the radiances observed at the location and time of the corresponding reference profile are calculated. The differences (that correspond to different 2003 reference profiles and different years from 2003 to 2012 for the analogues) are aggregated to provide an estimate of the annual mean difference. These differences between the spectral radiances, that are measured at different years and as such reflect different amounts of CO₂, are compared with theoretical estimates of the radiance impact of CO₂ Increase. To estimate the theoretical values, the spectral radiances corresponding to the reference temperature and water vapor profiles are simulated with different values of CO₂ concentration from 2003 to 2012 as measured by the NOAA Mauna Loa station [16]. The kCARTA forward model [17-18] is used to simulate the spectral radiances and is convolved with the AIRS spectral response functions to get theoretical AIRS radiances.

Figure 2 shows the spectral radiance annual mean differences due to CO₂ increase for the AIRS observations and the theoretical values. This figure is focused on the 680 to 780 cm⁻¹ spectral range, which is the spectral region where the CO₂ signal is most significant. In this spectral region, the enhanced absorption within the troposphere, where temperature decreases with height, leads to a reduction of the outgoing infrared radiation (less energy is emitted to space) which is behind the increase of global surface temperature and as such is a critical component of global warming. Figure 2 shows good agreement between theory and observations, with the observations following closely the theoretical impact of increased CO₂.

In summary, Ref. [14] developed a new methodology to disentangle the impact of CO₂ on observed infrared spectral radiances, from the effects of temperature and water vapor, in such a way as to provide a direct and more precise comparison with theoretical estimates of the radiance impact of CO₂. The

observations obtained using this methodology compare well with theory. This study provides an experimental confirmation from space of the direct effects of CO₂ on infrared spectral radiances. As such, these results confirm a critical theoretical foundation of the science of global warming.

Acknowledgements. This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration (8oNM0018D0004).

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GPC 2025 Executive Committee

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GPC Executive Committee Members-at-Large, Assigned Council Representative, and Newsletter Editor:

Left to right, top to bottom: Rachel Glade (3/2027), Juan M. Restrepo (3/2028), Renate Wackerbauer (3/2027), Monica Wilhelmus (3/2027), Pedram Hassanzadeh (3/2026), Tiffany Shaw (3/2026), Amrapalli Garanaik (Early Career, 3/2027), Shikhar Raj (Early Career, 3/2027), Council Representative (DFD) Howard A. Stone (3/2027), Peter Weichman (Newsletter Editor, 3/2026).



Removing Carbon Dioxide from the atmosphere to stop climate change: Can it really be done? – Continued from p. 1

Consumption of fossil fuels adds about 35 billion tons of carbon dioxide to the atmosphere each year. To remove just 3% of that addition — 1 billion tons — would require processing the equivalent of the entire volume of air over the state of Georgia to remove the carbon dioxide.

What are some ideas to accomplish this task? Physicists at the American Physical Society recently took a close look at the

problem. Most proposed methods are of one of two different types: “cyclic” and “once-through.”

Cyclic methods, such as direct capture, use energy to separate and concentrate carbon dioxide from either the air or the oceans. The basic laws of thermodynamics then tell us that an amount of electrical energy corresponding to that consumed by the state of Virginia in 2021 would be needed, at a bare minimum, to remove a billion tons of carbon dioxide. Inefficiencies would increase the necessary energy to exceed that consumed by California and Virginia put together.

Once-through methods require the spreading of vast amounts of alkaline materials, such as finely crushed basalt rock, over farmland or the oceans, speeding up the natural processes of rock weathering. Here the limiting factor is the amount of material required which at a minimum is comparable to the amount of coal that has burned. Again, much more material would likely be needed. To absorb a billion tons of CO₂ at least several times the amount of crushed rock produced each year in the United States would be needed. Though the large energy inputs of once-through methods are much less clear.

Another type of approach, involving capturing carbon dioxide by plants and storing it either in ecosystems or in underground storage can be viewed as either cyclic or once-through. Restoring ecosystems such as forests or wetlands is the least expensive approach but raises questions about the durability of storage and avoiding accounting tricks.

For any of these or other methods, we need to make sure we are measuring, verifying, and reporting how much carbon dioxide that is actually being removed from the air. We need to agree on international standards of accounting so we can trust the results.

We also need to make sure that any schemes that change the whole planet do not have unexpected side effects. The lines between carbon dioxide removal and more drastic geoengineering approaches, like solar radiation management such as stratospheric aerosol injection, are blurry.

Any method that changes large areas of land or ocean can change the amount of sunlight absorbed, which could heat the planet even more. It has been argued that reforestation can darken the land, canceling out a lot of the benefits from the trees taking in carbon dioxide.

I am worried that rock weathering might have the same problem (see <https://arxiv.org/abs/2501.01885>). On the other hand, maybe we could spread



Figure 1: Atmospheric carbon dioxide dissolves in rainwater forming carbonic acid. This acid reacts with many rocks including limestone — calcium carbonate — such as that found on Marble Mountain in the Klamath Mountains shown here. Rivulets etched into the limestone by the weak acid are visible at the bottom of the image. The reaction produces bicarbonate ions which can enter the oceans via rivers. This is part of Earth's natural carbon cycle that operates on geological time scales. Enhanced rock weathering and ocean alkalinity enhancement seek to speed up the reaction to remove atmospheric carbon dioxide on human time scales. Photo credit: Brad Marston

whitish rocks to reflect sunlight and cool Earth while absorbing carbon dioxide at the same time.

For more information, please see our report at URL <https://www.aps.org/publications/reports/atmospheric-carbon-dioxide-removal>

2025 APS Fluid Dynamics Meeting

The [78th Annual Meeting of the APS Division of Fluid Dynamics](#) will take place November 23-25, 2025 in Houston, Texas. The DFD meeting features a broad range of topics related to fluid mechanics, including several sessions devoted to geophysical fluid mechanics. These sessions include atmospheric and oceanic flows, sediment transport, glacial dynamics, turbulent flows, and microphysical process at the air-sea interface. As such, the GPC has made a sustained effort in the last several years to support and maintain a presence at the APS Division of Fluid Dynamics (DFD)

annual meeting. This has included sponsoring Mini-symposia and Focus sessions and sorting abstracts related to geophysical fluid dynamics.

We also started a new tradition in 2021, of an informal get-together on Monday evening during the DFD for all geophysical-interested conference participants. The GPC plans to continue this tradition in 2025!

For the 2025 DFD Meeting, the list of geophysical fluid dynamics sessions include:

Geophysical Fluid Dynamics: Atmospheric

Geophysical Fluid Dynamics: Oceanographic

Geophysical Fluid Dynamics: Air-Sea Interaction

Geophysical Fluid Dynamics: Climate

Geophysical Fluid Dynamics: Cryosphere

Geophysical Fluid Dynamics: Sediment Transport

Geophysical Fluid Dynamics: Rotating Flows

Geophysical Fluid Dynamics: Stratified Flows

GPC Nominating Committee:

Left to right: Valerio Lucarini (Chair), Dan Rothman, Tiffany Shaw, Hussein Aluie (Rochester), Pedram Hassanzadeh



The role of the Nominating Committee is to prepare a slate of candidates for the open elected positions each year. The Nominating Committee shall also respond with appropriate names to the Society's call for nomination for senior Society positions.

GPC Program Committee:

Left to right: Morgan O'Neill (Chair), Gregory Chini, Geoffrey Vallis, Xiyue (Sally) Zhang, Nicholas Lutsko



The role of the Program Committee is to work with the Executive Officers in scheduling contributed papers within areas of interest to the GPC and in arranging symposia and sessions of invited papers sponsored by the GPC at Society meetings. From time to time the Program Committee may also organize special GPC meetings and workshops, some with and some without the participation of other organizations.

GPC Elections

The GPC Nominating Committee, headed by past Chair [Valerio Lucarini](#), is in the process of putting together a diverse slate of outstanding candidates to run for leadership positions within the GPC Executive Committee. Prospective candidates will be considered for their scientific standing and activity, their history of involvement with GPC and the APS, their perspective on the activities of the Group, and their likelihood of service to GPC if elected. Diversity in the GPC leads to vitality and innovation. Identifying excellent candidates who can provide a broad view of the diverse field that is climate physics is key to maintaining the vitality of GPC.

There are five positions open for nominations:

Chair line: 4 years (progression from Vice Chair (currently [Gregory Chini](#)) to Chair-Elect (currently [Morgan O'Neill](#)) to Chair

(currently [Geoffrey Vallis](#)) to Past Chair (currently [Valerio Lucarini](#)), 1 position.

Member-at-Large: 3 years, 2 positions (replacing current members [Tiffany Shaw](#) and [Pedram Hassanzadeh](#)).

Junior Scientist Members-at-Large: (Graduate Student/Postdoc, replacing current members [Shikhar Rai](#) and [Amrapalli Garanaik](#)) 1 year, 2 positions.

The chair officers play a crucial role in providing leadership in organizing the scientific content of the March Meeting and other meetings and in representing climate physics within the American Physical Society.

The members-at-large constitute the fellowship committee; help select the invited symposia and invited talks for the March Meeting and provide advice on issues important to the GPC.

The Nomination Committee will select at least two candidates for each position, and will use suggestions from GPC membership as input for the process. It will be the task

of the Nomination Committee to contact potential slate members during construction of the slate to confirm a candidate's willingness to stand for election. GPC Members are invited to nominate top candidates for the aforementioned positions. A full list of current officers may be found on the [GPC homepage](#), and the [GPC Bylaws](#) list the officer duties and responsibilities.

Deadline for nominations is October 15, 2025, or until candidates are identified.

Nominations should be submitted using this [submission form](#). Self-nominations are encouraged. If you have any questions, please contact the GPC past chair, Valerio Lucarini (v.lucarini@leicester.ac.uk)

The election will be held in December 2025, and we strongly encourage you to help shape your GPC by voting. Elected candidates will begin their terms at the conclusion of the 2026 APS Global Physics Summit.

GPC Fellowship Committee:

Left to right: Greg Chini (Chair), Cesar Rocha, Justin Burton, Tiffany Shaw



The Fellowship Committee shall be chaired by the Vice-Chair and shall solicit nominations and propose candidates for APS Fellowship, shall review the qualifications of such candidates, and shall submit its recommendations to the Head of the Honors Program for the Society.

GPC Students and Early Career Investigators Awards

Five years ago, GPC created a scholarship for early career GPC members to attend the APS March Meetings and participate in the GPC sessions. For the upcoming 2025 APS March Meeting, GPC is offering two \$1,000 awards. The first award will be "The GPC Student Prize" and will be given to a graduate student member of the APS who is pursuing work related to the GPC mission. The second

award will be "The GPC Early Career Investigators Award" and will be given to an early career investigator (less than 5 years out of Ph.D.) who is a member of the APS GPC. Both awards will help defray the costs of attending and participating in a GPC related session at the APS Global Physics Summit. To apply for the awards, applicants should submit a single pdf file containing: (1) a maximum one-page statement that includes a brief description of the applicant's research, how participation would benefit

them, and how their work fits with the GPC mission, (2) a CV, (3) an abstract submitted to the upcoming APS Global Physics Summit.

Applications should be submitted to the APS OpenWater portal (please see [GPC Prizes & Awards page](#) for details). Awards will be announced in January 2026.

Deadline for applications: November 23, 2025.

Eunice Newton Foote Award Endowment

GPC continues to fundraise for the [Eunice Newton Foote Award Endowment](#). APS GPC is currently one of the few APS units without an APS-

level prize, nor is there an APS-level prize honoring research in climate physics. If we succeed in raising sufficient funds, this will become the second APS-level award whose name honors a female scientist, discounting early career awards. The first award was

the Mildred Dresselhaus Prize in Nanoscience or Nanomaterials, which was created by generous contributors.

Our initial goal is to raise \$150,000 to endow this award. [Please consider supporting](#) this important recognition.

Other News Links of Interest and Upcoming Events Calendar

1. GPC online seminar series, (organizational chair Justin Burton): <https://engage.aps.org/gpc/resources/seminar-series>.
2. [UN Climate Change Conference 2024](#) (UNFCCC COP 30), November 10-22, 2025, Belém, Brazil.

3. [AGU Annual meeting](#), Dec. 15-19, 2025, New Orleans, LA.
4. [106th American Meteorological Society Annual Meeting](#), Houston, TX, January 25-29 2025.
5. [European Geosciences Union General Assembly 2026](#), May 3-8, 2026, Vienna, Austria & Online.
6. The [One World Mathematics of Climate](#) is an online platform with the aim of gathering the best scientists from all

- over the world on the subjects of mathematics, theoretical physics, and statistical mechanics for modelling and understanding climate. The aim is to provide the best possible scientific discussions to a wide international audience. Upcoming speakers include: [Elisabeth Barnes](#) (Colorado State University), December 2.
7. [2026 Ocean Sciences Meeting](#), February 22-27, 2026, Glasgow, Scotland.