

GPC Newsletter

Issue #15

February 2021

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APS TOPICAL GROUP ON THE PHYSICS OF CLIMATE

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Message from the Editor

This is the fifteenth GPC Newsletter, 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.

Welcome from the GPC Chair

Mary Silber, University of Chicago

I'm writing to you from my home in Chicago, where I am hunkered down in both a pandemic and a polar vortex, and thinking about the intersection of epidemiology and climate science. Yesterday I "attended" a panel discussion at the APS leadership council meeting on "Communicating science to nonscientists in post-election and post-pandemic" [\(Continued on p. 2\)](#)

APS Fellows Nominations

APS GPC Members may nominate colleagues to become APS Fellows through GPC. You are invited to nominate those who have made exceptional contributions to promoting the advancement and diffusion of knowledge concerning the physics, measurement, and modeling of climate processes, within the domain of natural science and outside the [\(Continued on p. 2\)](#)

Message from New Lead Editor, Physical Review E

Uwe Tauber

Dear Colleagues in the APS Topical Group on the Physics of Climate:

I am writing to introduce myself as the new Lead Editor of Physical Review E (<https://www.aps.org/publications/apsnews/updates/tauber.cfm>). I believe a considerable range of the research pursued in your interdisciplinary field could fit well into PRE.

I am honored and delighted to succeed Eli Ben-Naim in this important role. Physical Review E is of course a truly interdisciplinary journal whose profile extends well beyond the traditional physics realm to a broad research community in science and engineering. I view this unique setting of PRE within the family of our community-run APS journals as both an [\(Continued on p. 2\)](#)

ARTICLE: Climate Impacts of COVID-19 Emissions Reductions via Aerosol-Cloud Interactions

Andrew Gettleman, National Center for Atmospheric Research

The COVID-19 pandemic resulted in 'lockdowns' worldwide in the first half of 2020. These changes to the global economy and movement of people changed fossil fuel and transport use. These changes thus had impacts on the emissions from these sources. Greenhouse gas emissions decreased nearly 20% in spring 2020, with an estimated annual decrease of about 8% (from the International Energy Agency). These changes also reduced pollution [\(Continued on p. 3\)](#)

Welcome from the GPC Chair

(Continued from p. 1)

America.” The importance of greater understanding of science, by the public, was highlighted by the panel through the examples of anti-maskers/anti-vaxxers and climate change deniers.

How’s that for an opening example of the intersection of climate and the pandemic?

For almost a decade now I have been involved with a “Math and Climate Research Network” that has, in recent years, run summer workshops and yearlong research activities for mathematics students who want to explore the intersection of applied math (my field) and climate research. Drawing on our mathematical areas of expertise, we explore topics such as possible mechanisms for tipping points and predictability barriers, and we introduce students to algorithms for data assimilation. Last summer we abruptly pivoted to running a 6-week program on “Dynamics and data in the COVID-19 pandemic”. We did this, remotely, through the American Institute of Mathematics, who provided a summer stipend to the students, many of whom had summer internships cancelled by the pandemic.

A few of the student teams were interested in the interface between climate and the pandemic; for example, examining proxies for quantifying reduction in CO₂ emissions during the lockdown. They were hoping the pandemic would teach us what is possible, with a tweaking of lifestyle.

Yes, the pandemic has helped us, individually, decrease our carbon footprint. We have learned new ways to work, many of which are improvements and here to stay. We have explored new research questions, and some have found opportunities for answering scientific questions about climate created by changes in air quality during lockdown. (See the newsletter article by Andrew Gettelman.) I’m also thinking about what is critically lost in my work-space. I miss the serendipity of chance encounters. I miss the conversations that are spontaneous, rather than scheduled to occur via Zoom. Chance encounters, and the ideas that arise through them, often spark our creativity and our curiosity.

Almost exactly one year ago I attended the APS Leadership meeting in Washington DC, as chair elect for the GPC. I was there with Bill Collins, now

our past chair, and Raymond Shaw, our secretary-treasurer. One of the serendipitous encounters I had at the Leadership meeting was actually with a colleague from the University of Chicago, Tom Witten. We met at the airport, en route to Washington, and sat together on the flight. Tom pulled out a manuscript he was working on with some students, in which he was looking at time-series temperature data across the US, extracting the second harmonic content of the annually oscillating signal. Fast forward a year, Tom will present that work as a contributed talk in a GPC focus session at this year’s March Meeting. It is a session that is jointly sponsored by the Group on Statistical and Nonlinear Physics that Tom chairs. I organized it with Justin Burton, who is a GPC member-at-large, that I met with when he was visiting U. Chicago to give an “in-person” talk. Remember the olden days, when we didn’t have “in-person” and “remote” as essential parts of our vocabulary?

I hope you will join us at the APS March meeting, and help to create some serendipitous encounters for the GPC, across time-zones and climates.

APS Fellows Nominations

(Continued from p. 1)

domains of societal impact and policy, legislation, and broader societal issues. Selection as an APS Fellow by one’s professional peers is a great honor. The number of Fellows elected annually cannot exceed 0.5% of Society membership.

Any current APS member can initiate a nomination. The membership of APS is diverse and global, and the Fellows of APS should reflect that diversity. Fellowship nominations of women, members of underrepresented minority groups, and scientists from outside the United States are especially encouraged.

For information on how to nominate, and a list of current Fellows, please see the [APS Fellows webpage](#).

The deadline for submitting fellowship nominations for review by the GPC Fellowship Committee is [June 1, 2020](#). For further information regarding fellowship nominations, please email fellowship@aps.org

Message from New Lead Editor, Physical Review E

(Continued from p. 1)

opportunity and challenge. Naturally, I will have to profoundly rely and draw on your expertise, excellence, and dedication, and I look forward to working with the GPC leadership over the coming years!

PRE covers a huge range of topics, yet all address complex interacting many-body systems, typically subject to nonlinear, often stochastic collective dynamics, and usually (but not exclusively) in the classical realm, and whose analytical and/or numerical exploration tends to rely on statistical approaches. We invite the best topical manuscripts in these broad areas that

advance the field and represent an authoritative and substantive addition to the body of literature by presenting important and novel physics. We expect papers published in PRE to make a significant contribution in a specific research area and generate interest for our readership, and to explore the addressed subject matter comprehensively and thoroughly.

Work that addresses the physics of climate could fit very nicely into PRE: there is natural overlap with nonlinear and statistical physics, complex systems, computational physics, fluid dynamics, plasma physics, and data science, all fields that are covered prominently within the interdisciplinary scope of PRE. Especially if you wish to emphasize connections with many-body problems, correlation effects, non-equilibrium features, innovative statistical or computational tools, etc.,

I would think PRE may be a good match.

The quality of every journal of course crucially depends on the submissions it receives but also decisively on the quality of its referee pool. Please aid our fundamental mission to disseminate the best research by serving as diligent, conscientious, and timely reviewers, and by recruiting and training students and postdocs for our reviewer pool.

We also rely very much on the amazing collective expertise among the APS

units to help us stay up to date with our journal scope as, e.g., reflected in its section headings, and I generally would like to maintain an intense open discussion line with all of you to further improve our operations and service to the scientific community in general, and to physicists engaged in climate science specifically.

Please always feel free to contact me with any suggestions, ideas, concerns, or any other issues.

Uwe Tauber, tauber@aps.org

GPC 2021 Executive

Chair
(through 12/2021):



Mary Silber
Department of
Statistics
University of Chicago
Chicago, IL 60637
msilber@uchicago.edu
[u](#)

Chair-Elect
(through 12/2021)



William Newman
Department of Earth,
Planetary, and Space
Sciences
UCLA
Los Angeles, CA
90095
win@ucla.edu

Vice Chair
(through 12/2021)



Hussein Aluie
Department of
Mechanical
Engineering
University of
Rochester
husein@rochester.edu

Past Chair
(through 12/2021):



William D. Collins
Division Director
Climate &
Ecosystems Sciences
Lawrence Berkeley
National Laboratory
wcollins@lbl.gov

Secretary/Treasurer
(through 12/2021):



Raymond A. Shaw
Department of
Physics
Michigan Technical
University
1400 Townsend Dr
Houghton, MI 49931
(906) 487-1961
rashaw@mtu.edu

Article: Climate Impacts of COVID-19 Emissions Reductions via Aerosol-Cloud Interactions (Continued from p. 1)

associated with fossil fuel emissions. Emissions of air pollution from transport emissions were the most obvious change (such as nitrogen oxides). But particulate emissions of human generated pollution such as Black Carbon (BC, colloquially 'soot') and sulfate (SO₄) also decreased.

The effect of reductions in fossil fuel emissions was a small cooling tendency on the planet. Because carbon dioxide (CO₂) perturbations

remain in the atmosphere for a hundred years, a one year change of ~10% is a very small effect. But aerosols are also important for climate. BC is important for the direct absorption of radiation which can heat the atmosphere and surface below. Sulfate scatters visible light, and thus is a cooling effect by scattering some sunlight back to space. Both BC and SO₄ also have potentially substantial 'indirect' effects on climate. These aerosols act as Cloud Condensation Nuclei (CCN) and are locations for forming liquid cloud drops and ice crystals. Decreases in aerosols would

tend to result in fewer cloud drops and crystals. What does this mean for climate?

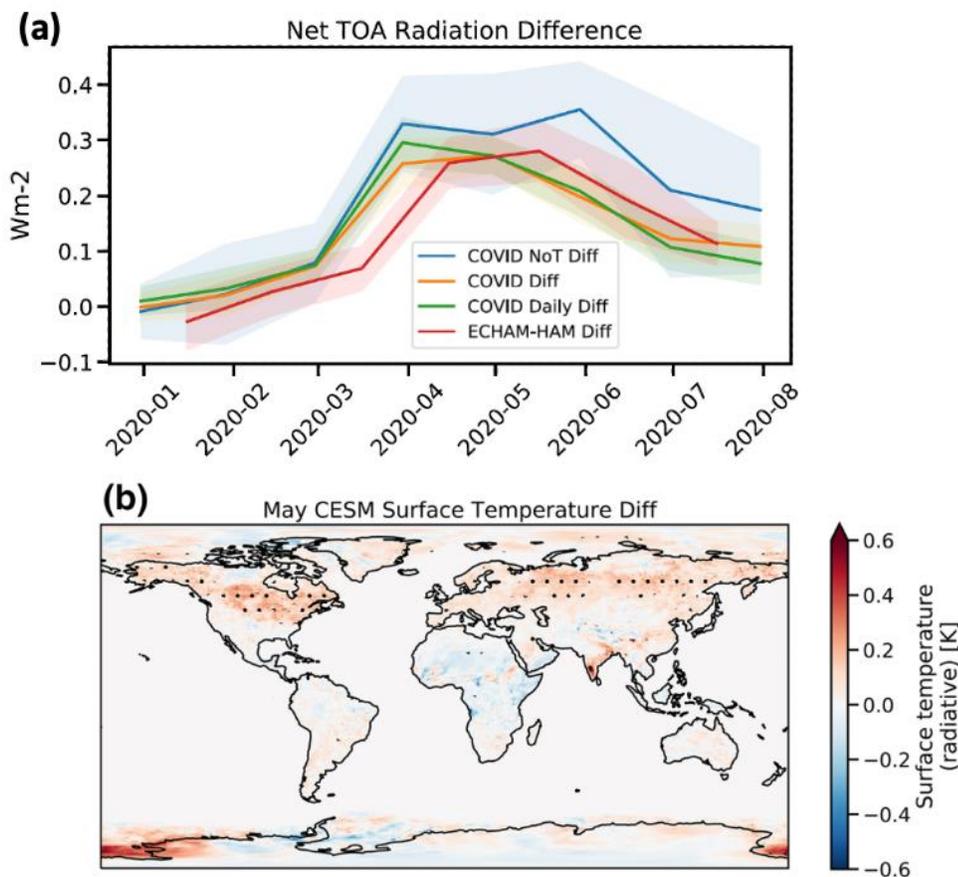
First, we must understand the role of clouds in the climate system. Clouds are white, and clouds are cold. Low clouds act like a shade, scattering sunlight (shorter visible wavelengths) from their bright white tops that would otherwise be absorbed by a darker surface below. Clouds also absorb infrared radiation from the earth below, acting like a blanket. For low clouds, since they are close to the temperature of the surface, the blanket is not a large warming effect.

For high clouds with cold tops, they absorb radiation from below and emit it in both directions at a lower temperature, acting like a blanket. The blanket is substantial, and usually a little bit larger than their solar cooling effect. So on balance, low clouds cool the planet, and high clouds warm the planet, with the net result a strong cooling of 6 times the effect of doubling CO_2 (25 W/m^2 cooling for clouds, versus about 4 W/m^2 warming for doubling CO_2).

So what happens when you reduce the number of cloud drops? The drops get bigger. Bigger drops are 'darker': if you think of a cloud, the darker gray parts usually have bigger drops. This reduces the cloud cooling effect and would thus be a net warming.

Back to COVID changes. As aerosols (BC and SO_4) decreased, we would expect reductions in direct scattering and absorption, and also reductions in cloud drop number. What are the climate effects of this? To explore this question, we used a special configuration of two Earth System Models (Climate Models) focusing on the atmosphere. This work recently appeared in [Geophysical Research Letters](#).

We used two different models (one from the US, one from Europe) of similar complexity to simulate the changes in radiation and temperature resulting from aerosol emissions changes. We used as input changes to emissions derived from Google mobility trends: the change in where phones were located all over the planet. These mobility based estimates were calibrated against spring 2020 emissions data on fossil fuel use. The result was a method that could be applied nearly globally to estimate emissions reductions. The unique aspect of this study is we use simulations 'constrained' by actual meteorology over 2020 to remove the effects of meteorological noise from the simulations. At each time step we push the models back to the observed



(a) Monthly global mean time series of top of atmosphere radiation differences due to COVID-19 lockdowns. COVID-19 ensemble (COVID, orange), no temperature nudging (COVID NoT, blue), daily emissions with temperature nudging (COVID Daily, green) and ECHAM-HAM simulations (ECHAM-HAM, red). (b) May 2020 simulated temperature difference in CESM as the difference between COVID-19 and control ensemble means without temperature nudging. Stippled regions are significant differences using a False Discovery rate t-test at 90% confidence.

'weather' state. This results in the ability to find statistically significant changes in clouds and radiation much smaller than could be seen in observations because of year to year variability.

The study found that significant changes in simulated aerosol emissions led to reductions in total anthropogenic aerosol cooling through aerosol-cloud interactions. Cloud drop numbers were reduced in the simulations and liquid water path decreases. This leads to a dimming of clouds and a net warming effect. Panel (a) in the figure shows how this evolved over the months of 2020 with 2 models (Orange, Blue, Green one of the models; Red the other model), with some sensitivity tests for different

emissions frequency (daily versus monthly) and constraining temperature or not. The combined average effect is small ($+0.29 \pm 0.15 \text{ W/m}^2$) and peaks in April-June 2020. Both models give a similar estimate, that the total human cooling effect (-1.5 W/m^2 or so) was reduced about 20%, for a small net warming.

The magnitude of these changes is regionally significant in radiative and cloud properties only when tightly constrained simulations nudged to meteorology are used. The differences from baseline are much smaller than year to year variability in radiative and cloud properties due to meteorology, and thus not directly detectable from observations.

Though the simulations use fixed ocean temperatures, surface temperature over land can vary. Accordingly, the fast radiative response from clouds and aerosols does cause regional changes in surface temperature on the order of +0.1 to +0.3 K, mostly at higher northern hemisphere latitudes over the US and Russia in spring [panel (b) of the figure]. However, this result does not account for all the earth system dynamics or the slower response as the ocean interacts with radiation. To assess the long term response but limit noise, we put the aerosol warming effect derived here into a coupled climate model emulator. The impact of these aerosol changes on global

surface temperature is estimated to be very small (+0.03 K peak) and transient over several years. However, the aerosol changes are the largest contribution to COVID-19 affected emissions induced radiative forcing and temperature changes. Aerosol changes are larger than the cooling from reductions in CO₂, contrails or ozone.

Interestingly, 2020 was by some estimates the warmest year on record. +0.03 K is about 1/3 of the recent interannual variability of the global average mean temperature: indicating that maybe the reduction in pollution (aerosols) and resulting warming

might have pushed 2020 over the edge into being the warmest year ever.

What does this mean for the future? We account for these effects in our current climate model projections. We assume that the air will be cleaner, and this will cause a net future warming. But the processes involved are highly uncertain due to the scales (cloud drops and particles at micro-meter scales). That makes it harder for us to constrain future warming. As we get more detailed observations from 2020, we might be able to use the unintended experiment of COVID pollution reductions to test the effects described here.

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

Left to right: Ching-Yao Lai (12/2023), Steve Tobias (12/2023), Katie Dagon (12/2021), Daniel Rothman (12/2021), Juston Burton (12/2022), Albion Lawrence (12/2022), Student Member Adria Schwarber (12/2021), Assigned Council Representative (DFD) Howard A. Stone, Peter Weichman (Newsletter Editor, 12/2021).



GPC Program Committee:

Left to right: Chris Forest (Chair), William Collins, Norman Loeb, Maria Rugenstein, Mark Zelinka



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.



The two **GPC Focus Sessions** will take place Thursday, March 18. The **GPC Business Meeting** will take place 6-7 pm that evening.

GPC Early Career Prizes: Two GPC early career prizes were awarded this year. The recipients were focus session contributed talk presenters Dallas Foster, a graduate student at Oregon State University ([An Improved Framework for the Dynamic Likelihood Filter](#)), and Srikanth Topaladoddi, a postdoc at University of Oxford ([Statistical Mechanical Theory of the Thickness Distribution of Arctic Sea Ice](#)). The awards cover March Meeting registration fees.

GPC Student Chat with the Experts: The student chat with expert events will take place 12:30-2:00 pm CST on Tuesday, March 16. Each online table will include up to eight students. The role of the expert is to speak informally on a chosen physics topic. It is a great opportunity for students and experts to have a conversation without any presentations or formality. Bill Collins will host the GPC table, which will be devoted to the topic "Connecting physics and physicists to solutions for climate change."

GPC Focus Session: Rare Events, Tipping Points, and Abrupt Changes in the Climate System

Session R15, 8:00 – 11:00 am CDT, Thursday, March 18

Invited Talks:



FREDDY BOUCHET
ENS de Lyon and CNRS

Title: [Large deviation theory, extreme events and abrupt changes in the climate system](#)

Synopsis: In the climate system, many events of primary importance, for instance rare extreme events or rare transitions between climate attractors cannot be studied with conventional approaches, because they are too rare and the realistic models

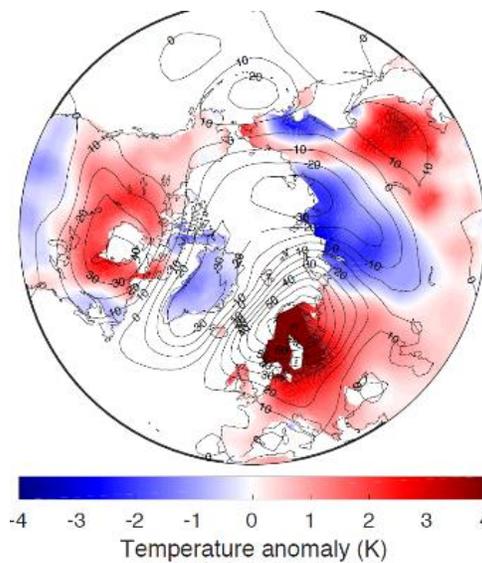
are too complex. We will discuss several new algorithms and new theoretical approaches based on large deviation theory, where huge progress has been made to compute such rare events. We discuss results for the study of extreme heat waves and abrupt climate changes. We will delineate a research program in order for these approaches to be used with the most realistic models in the future in order to pave the way of a quantitative science of rare climate events.

*Some of the research leading to these results has received funding from the European Research Council under the European Union's seventh Framework Programme

Extreme teleconnection pattern: averaged north hemisphere temperature (colors) and 500hPa geopotential height (lines), conditioned on the occurrence of an extreme heat wave over Europe. The picture shows clear global correlations for the occurrence of a local heatwave. Gathering the very long statistics for this picture was possible thanks to the use of a rare event algorithm.

(FP7/2007-2013 Grant Agreement No. 616811). Some through the ACADEMICS grant of the IDEXLYON, project of the Université de Lyon, PIA operated by ANR-16-IDEX-0005. The computation of this work were partially

performed on the PSMN platform of ENS de Lyon. This work was granted access to the HPC resources of CINES under the DARI allocations A0050110575 and A0070110575 made by GENCI





JUAN RESTREPO

Computer Science and Mathematics Division, Oak Ridge National Laboratory

Title: [Data Assimilation and Uncertainty Quantification in the Geosciences](#)

Synopsis: In the statistics community “Big Data” science is meant to suggest the combining of inferential and computational thinking. We also speak of big data in the geosciences. However, the problems we pursue, e.g. Earth’s climate, are often extreme in the number of degrees of freedom, and in many instances, non-stationary in their statistics. This usually means that we are working with sparse observational data sets, even if the number of

observations is large. The Bayesian framework is a natural inferential data assimilation strategy in geosciences, to some extent because the degrees of freedom in the problem vastly outnumber observations but more critically, because the models we use to represent nature have considerable predictive power. Data sparsity is thus mitigated through physics-informed models.

After presenting a review of this Bayesian estimation strategy we will summarize how this process has evolved to handle nonlinear and non-Gaussian processes. We will also suggest that it is possible to design estimators to highlight certain features or exploit structure in the dynamics or the physics. An example of an approximate Bayesian estimator informed by models and future data will be shown to lead to improvements in forecasts. Machine



The complexity of accurately predicting the track of hurricanes in time to respond to their potential socio-economic impact. A long-term goal is to reduce the risk/uncertainty of these tracks to allow for responders to station their resources within a short driving distance of the most affected population areas. *Image from NOAA.*

learning can be exploited to capture unknown or unresolved processes and made to work with these estimators. We will conclude the presentation with a review of present challenges, encompassing multiscale

dynamics and statistics, unresolved physics, and event forecasting. *This work is supported by the National Science Foundation and by GoMRI.

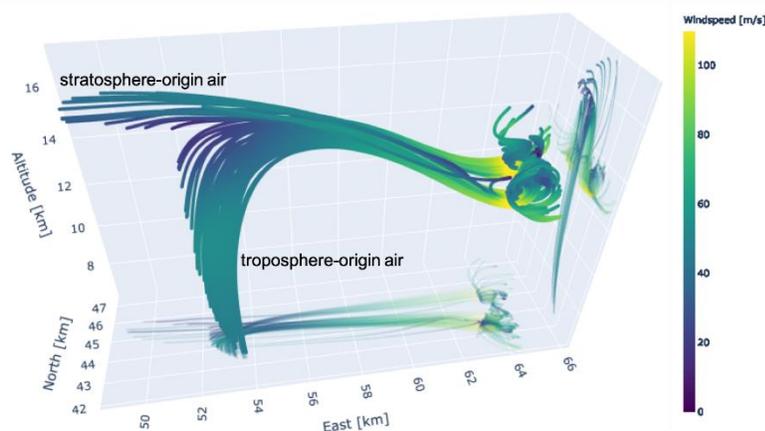


MORGAN O'NEILL

School of Earth, Energy & Environmental Sciences Stanford University

Title: [Feedbacks between the worst storms on Earth and lower stratospheric water vapor](#)

Synopsis: The presence of water vapor in the lower stratosphere is enormously consequential for climate. Physically, it helps set the ‘cold reservoir’ temperature effectively experienced by the tropospheric heat engine, and an increase in water vapor in the lower stratosphere cools the stratosphere and warms the Earth’s surface. Chemically, an increase in stratospheric water vapor speeds ozone destruction. The



Subset of Lagrangian air parcels that reach at least 110 m/s in the lee of a supercell thunderstorm’s overshooting top, suggestive of a hydraulic jump

stratospheric water budget remains poorly constrained, both observationally and

theoretically. Strong thunderstorms are known to be an important secondary source of water vapor to the lower stratosphere, and how they may feedback to large scales in a warming climate is almost completely unknown. The most severe midlatitude supercell thunderstorms typically feature an Above-Anvil Cirrus Plume (AACP),

which is a wake of ice and water vapor downstream of overshooting deep convection, several kilometers above the main anvil shield. The AACP is uniquely capable of lofting water high above the tropopause. Using high-resolution large eddy simulations, we show that the AACP is formed by the development of a hydraulic jump at the tropopause, which occurs

under specific atmospheric conditions. Immediately upon the jump onset, the simulated water vapor injection rate into the stratospheric overworld increases from less than 1 ton/s to greater than 7 ton/s, accompanied by horizontal windspeeds that top 110 m/s. The presence of a small-scale, dynamical threshold past which only some storms become very effective

local hydrators of the lower stratosphere suggests a blind spot in large-scale climate models unable to resolve this behavior. The feedback on the environmental conditions for future storms due to a humidified lower stratosphere is an exciting area of future research.

Contributed Talks:

Vera Melinda Galfi, Valerio Lucarini	<u>Fingerprinting Heatwaves and Cold Spells and Assessing Their Response to Climate Change using Large Deviation Theory</u>
Constantin Arnscheidt, Daniel Rothman	<u>Asymmetric extreme events of Earth's climate and carbon cycle during the last 66 million years</u>
Justin Finkel, Jonathan Weare, Dorian Abbot	<u>Transition path theory analysis of noise-induced tipping in a stratospheric model</u>
Jake Fontana, Paul Johns, Peter Palffy-Muhoray	<u>The distribution of ocean surface wave heights and the St. Petersburg paradox</u>
Dallas Foster, Juan Restrepo	<u>An Improved Framework for the Dynamic Likelihood Filter</u>
Gregory Eyink, Dmytro Bandak, Alexei Mailybaev, Nigel Goldenfeld	<u>Spontaneous Stochasticity in Atmospheric Turbulence and Climate Dynamics</u>

GPC Communications Committee

Left to right: Peter Weichman (Chair), Barbara Levi



The role of the Communications Committee is to have oversight of the Newsletter and any other publications that may be established by the GPC. The Communications Committee shall also be responsible for keeping the physics community and other interested communities informed about climate physics issues, activities, and accomplishments through the Newsletter, GPC website and email messages.

GPC Focus Session: Statistical and Nonlinear Physics of Earth and Its Climate

Session S15, 11:15 am – 2:15 pm CDT, Thursday, March 18

Invited Talks:



DANIEL ROTHMAN

Earth, Atmospheric, and Planetary Sciences MIT

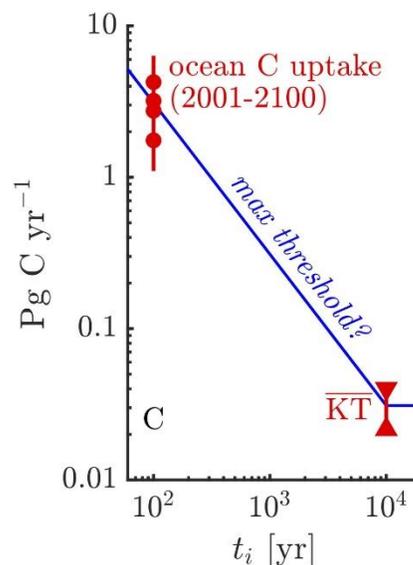
Title: [Characteristic Excitations of Earth's Carbon Cycle](#)

Synopsis: Over geologic time, Earth's carbon cycle has been intermittently disrupted by transient changes in the oceans'

store of carbon. Each of these events co-occurs with significant climate change; moreover, mass extinctions are always accompanied by such disruptions. Yet the cause of all of these events remains mysterious. Disruptions of the carbon cycle are typically assumed to represent a proportionate response to an external stressor, such as enhanced volcanism or the release of methane. This talk reviews a combination of empirical evidence and physical theory that suggests instead that many of these events are characteristic nonlinear responses of the Earth system to relatively minor perturbations. Two

kinds of observations support this conclusion: the existence of a characteristic carbon flux in the surges that mark these events, and a tendency of minor events to occur in pairs. Both observations are consistent with the predictions of a model of an excitable carbon cycle.

*This work was supported in part by the Lorenz Center



Comparison of estimates of the perturbations of the modern and end-Cretaceous (KT) carbon cycles (red symbols) to a hypothesis for the upper bound of a threshold for nonlinear excitation (straight line), as a function of the duration of time t_i over which the



ALISON BANWELL

Cooperative Institute for Research in Environmental Sciences (CIRES) University of Colorado, Boulder

Title: [Impacts of surface melt and hydrology on Antarctic ice-shelf dynamics and break-up](#)

Synopsis: Ice shelves, which are thick floating layers of glacier ice

extending from the glaciers on land, buttress much of Antarctica and protect the ice sheet from greater rates of mass loss than it is already experiencing. However, field, remotely-sensed, and modeling based data suggest that the stability of these ice-shelves is threatened due to stress variations associated with surface meltwater ponding and drainage. These processes may initiate meltwater-induced vertical fracturing ('hydrofracturing') and iceberg capsize, which may ultimately lead to ice-shelf disintegration. For example, the rapid and



Meltwater lakes on the surface of the George VI Ice Shelf, Antarctic Peninsula, in January 2020. Photo: Thomas Simons.

widespread collapse of the Larsen B ice shelf in 2002 was likely driven by the drainage of about 3000

lakes via a chain reaction style process. Surface melting and ponding on the surfaces of

Antarctic ice shelves is becoming increasingly widespread, and melt rates are predicted to increase significantly this century. Although the most up to date ice-sheet models do not account for the effects of meltwater ponding on ice-shelf stability explicitly, these models respond dramatically to increased

ice-shelf melting, predicting up to 1 m of sea-level contribution from Antarctica this century. By focusing on a variety of field, remotely-sensed and modeling based case studies drawn from my research, I will present recent progress and future research directions in the rapidly growing field of

Antarctic ice-shelf surface hydrology and stability. Such case studies will include: i) the first field-based study of ice-shelf flexure in response to the filling and draining of surface lakes; ii) an optical and microwave satellite data based study showing 32-year record melt on the George VI Ice Shelf in the 2019/2020 austral

summer; and iii) results from a new process-scale ice shelf model that simulates, for the first time, both ice flow and viscoelastic flexure in response to a variety of surface meltwater phenomena.
*NSF award #1841607 to the University of Colorado Boulder (PI Banwell).



REBECCA JACKSON
School of Environmental and Biological Sciences
Rutgers University

Title: [Melting and mixing at the ocean-glacier interface](#)

Synopsis: Around the globe, glaciers and ice sheets are shrinking and contributing to sea level rise. Ocean warming has been implicated as a driver of glacier retreat, with submarine melting as the

presumed link. However, at the termini of tidewater glaciers, we lack observations of submarine melting or the oceanic processes that control melt. Instead, many studies rely on untested theory and parameterizations to estimate submarine melt rates. These frameworks often hinge on buoyant plumes, whose small-scale dynamics can modulate both the ocean's impact on the glacier via submarine melting and the glacier's impact on the ocean via buoyancy forcing. In this talk, I will present data collected near the terminus of LeConte Glacier, Alaska to probe the standard theory for plume-driven melt. In the first half, I will present surveys from autonomous

kayaks that reveal ubiquitous meltwater intrusions along the terminus and suggest a mechanism to explain melt rates that are significantly higher than standard theory predicts. In the second half, the bulk fluxes of submarine melt and subglacial discharge are evaluated across a wide

range of conditions in six field campaigns to test the theoretical relationship between these two sources of freshwater. Modifications to the standard melt parameterizations are explored, in an effort to work towards an updated representation of melt in ocean-glacier models.



Autonomous kayak collecting measurements of ocean properties and currents in front of LeConte Glacier, Alaska.

Contributed Talks:

Yunxiang Song, Thomas Witten, Kyle B. Lawlor	"Excess" semiannual variation in historic temperature records
Justin Burton, Cassotto Ryan, Joshua Mendez Harper, Jason Amundson, Mark Fahnestock, Martin Truffer, Marc Guasch	Granular decoherence precedes failure of glacial ice mélange
Peter Weichman	Enhanced deep water acoustic range estimation based on ocean General Circulation
William Balch, Christian Pappas, Arjang Geramifard, Madhu Gyawali, Lok Lamsal, Bimal Gyawali, Chloe Vieira, Andre Wright, Rudra Aryal	Space and Ground-Based Decadal Trends of Nitrogen Oxides in Texas

Lily Liu, Punit Gandhi, Mary Silber	Banded Vegetation Patterns in Drylands: Modeling across timescales
Srikanth Toppaladoddi, Woosok Moon, John Wettlaufer	Statistical Mechanical Theory of the Thickness Distribution of Arctic Sea Ice

Other News Links of Interest and Upcoming Events Calendar

1. [2021 International Conference on Clouds and Precipitation](#), San Francisco, USA, November 1-2, 2021