GPC Newsletter
Issue #9
February 2018

IN THIS ISSUE

APS TOPICAL GROUP ON THE PHYSICS OF CLIMATE

Message from the Editor

This is the seventh 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

Michael E. Mann, Pennsylvania State University

Welcome to the Spring 2018 GPC Newsletter.

We have a number of items of interest including an essay by Juan Restrepo and myself, *This is How "Climate is Always Changing,"* that attempts to place some of the recent public discourse over climate change in a rigorous, physically-based context. In an attempt to extend our voice further, GPC now has its own Twitter account, which may be followed for announcements about our meeting sessions, newsletter, etc. Please follow us at @APS_GPC!

(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 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.

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GPC Bylaw Amendment Proposal

The Executive Committee of GPC has prepared a Proposal to Amend the GPC Bylaws. The amendment covers three areas:

1) Amend the bylaws to conform to Society governance documents and to reflect governance best practices.

2) Amend the bylaws to decide all elections, except for the election to the position of vice chair, by a plurality of votes cast rather than a majority for all ballot positions.

(Continued on p. 2)

ARTICLE: This is how "Climate is Always Changing"

Juan M. Restrepo, Oregon State University, and Michael E. Mann, Penn. State University

The Fourth National Assessment, Climate Science Special Report of the US Global Change Program, published in November 2017, concludes, "based on extensive evidence, that it is extremely likely that human activities, especially emissions of greenhouse gases, are the dominant cause of the observed warming since the mid-20th century."

(Continued on p. 2)

Welcome from the GPC Chair

(Continued from p. 1)

We are *very* excited about the upcoming March APS Meeting in LA (the city, rather than the state, this year!). The meeting will feature two formal scientific sessions sponsored by the Topical Group on the Physics of Climate, both on Tuesday March 6. Beginning at 11:15 am, we have our Invited Session F16 on "Energy Flows in The Climate System" will be held in room 305. Speakers Martin Mlynczak, Sarah Purkey, Katharine Ricke, John Dykema, and Ron Miller will examine various aspects of radiative forcing and energy balance, including topics such as scattering by aerosols and dust, solar geoengineering, deep ocean heat storage, and the spectroscopic foundation of radiative forcing from carbon dioxide. At 2:30 pm, Hussein Aluie will chair Focus Session H46 on "Multi-Scale Flows and Pathways in the Climate System" featuring two invited speakers and nine contributed talks dealing with the role of geophysical fluid dynamics in climate. The Focus session will be held in room 506. More details about the two scientific sessions can be found inside this Newsletter.

The GPC Business Meeting (Session J39) will follow at 5:45 pm at a location to be announced. All GPC members are invited to participate.

I would like to thank colleagues whose terms on the Executive Committee finished at the end of 2017 for their hard work. Juan Restrepo put together an impressive slate of candidates for our election in his capacity as Chair of the Nominations Committee, while past Chair Brad Marston has helped out in numerous ways, and is a powerful voice for GPC as a member of the APS Board of Directors. We are pleased to have more diversity on GPC committees than ever before and the vital participation of early career scientists. We welcome Katie Dagon of Harvard and Karen McKinnon of NCAR as new members of our Program Committee and we welcome our new Executive Committee members Barbara Levy, Isabel McCoy, and Bill Collins. We would also like to thank outgoing members-at-large Mark Boslough and Raymond Shaw for their service.

You are cordially invited to the GPC Climate Café to take place immediately following the GPC business meeting. This is an informal meeting where, over drinks and food, you can meet the March Meeting GPC speakers, as well as fellow GPC and other APS members. We'll discuss climate science, network, and chat with the Executive Committee members about GPC concerns. In keeping with the informal nature of the cafe, we will announce the venue for this year's Climate Cafe at the Tuesday sessions. All APS members are welcome to attend.

We look forward to seeing you in Los Angeles!

APS Fellows Nominations

(Continued from p. 1)

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 Thursday, June 1, 2018. For further information regarding fellowship nominations, please email fellowship@aps.org.

GPC Bylaw Amendment Proposal

(Continued from p. 1)

3) Add a new position for a graduate student member of the Executive Committee, per Council resolution of November 2017.

An opportunity to discuss the Amendment will be given at the next GPC Business Session scheduled at the March Meeting on Tuesday, March 6 at 5:45 pm in room 501B of the Los Angeles Convention Center. You may also E-mail your comments before then and they will be shared with the Executive Committee and other attendees of the Business Session.

This is how "Climate is Always Changing"

(Continued from p. 1)

When asked about some of the conclusions in the report regarding systematic climate change, Mr. Raj Shah, a spokesman for the Trump administration, stated, ``The climate has changed and it is always changing. [As the report] states, the magnitude of future climate change depends significantly on remaining uncertainty in the sensitivity of Earth's climate to greenhouse gas emissions." [1].

Shah is echoing assertions from other observers that there is nothing unusual about the changes in climate and weather that we are experiencing: There have been changes before the industrial era, and some of these have been extreme. Translated to more technical terms, such observers claim that climate has a stationary distribution – one that does not change with time – and that, in recent years, we just happen to be experiencing samples of this distribution that are, possibly rare, extreme highs.

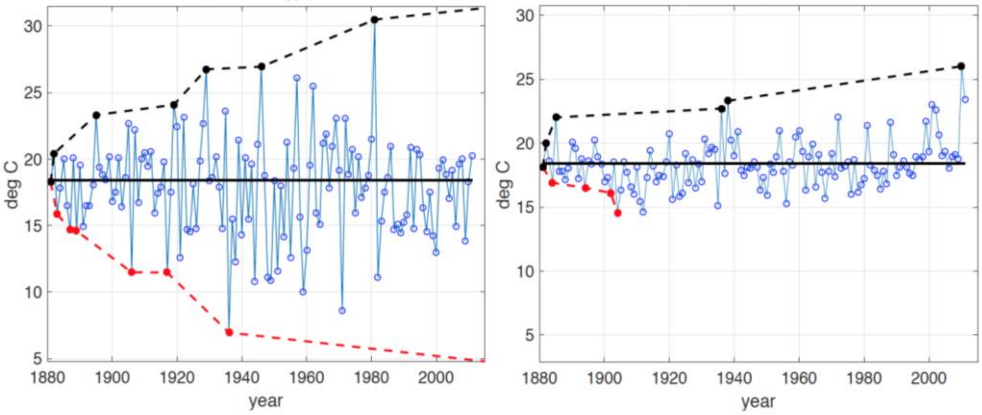

Figure 1: (left) records in a synthetic stationary distribution, (right) records of July monthly temperatures at the Moscow station

One way to evaluate whether climate has a stationary distribution is to examine whether climate data obeys a theorem that applies to stationary distributions. We will apply to temperature data a theorem in statistically stationary distributions that yields rates of record values in a random time series. Others have used this approach more rigorously to examine trends in climate data [2, 3, 4]. Since the only requirement made in the theorem on the random variables is that they derive from a stationary distribution, the failure of this theorem to hold indicates that the distribution from which this data arises is not stationary. The theorem or its application does not yield causal attributions to its outcomes. Nevertheless, the use of such a simple test circumvents the necessity to argue about data statistics based upon model outcomes.

Before proceeding we should clarify what is meant by climate, as opposed to weather. Climate and weather really describe the same system, but the term 'climate' refers to large spatio-temporal scales and 'weather' to small ones. This distinction is not just a convenience. While both describe the energetics, mass and momentum exchanges of a rotating Earth, the scale determines the prominence of the different phenomenology, weather being dominated by inertial effects (turbulence, waves, density dynamics, and transient and sometimes unstable conditions) and climate by the forced/dissipative effects (radiation and ocean and atmospheric transport). Weather includes tornados, hurricanes, or extreme values of temperature or rainfall. Examples of climate are the seasons, El Niño/Southern Oscillation, the ice ages and Industrial Era global warming.

Records in Time Series

We make the following assertion: climate temperatures are samples from a stationary distribution. If so, a theorem that applies to stationary distributions should be borne out by the data. We apply a theorem about record highs and record lows (see [5]).

One draws a sequence of independent and identically-distributed (IID) samples $X_1, X_2, X_3, \ldots$ from a stationary distribution. We denote a sample from the sequence a *record* high (low) if its value is higher (or lower) than the samples preceding it. The probability of a record high is $P_n := \mathrm{Prob}[X_n > \max\{X_1, X_2, \ldots, X_{n-1}\}]$ (with the obvious modifications for the record low). In a sample set of size n any one particular value has equal chance of being the greatest (lowest) value, thus $P_n = 1/n$. We denote as $\mathrm{E}(R)$ the expected number of records for a stationary random sequence of size n. It is given by the harmonic series $E(R) = 1 + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{n}$. For large n, $\mathrm{E}(R) = \gamma + \log(n)$, where γ is the Euler constant.

The occurrence of record values in climate data has been carefully compared to predictions for a

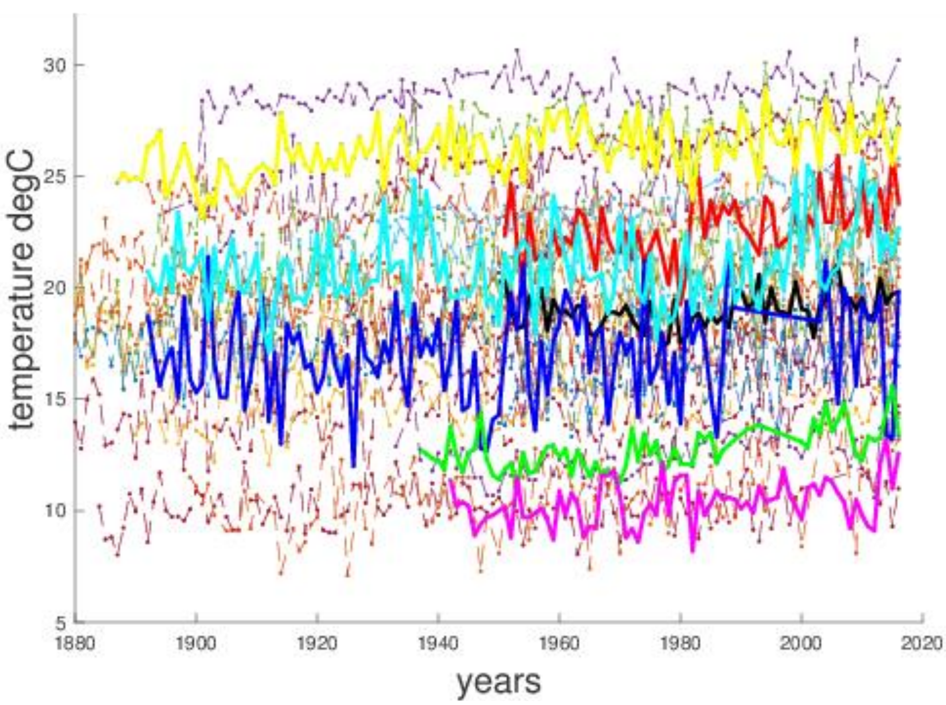

Figure 2: Temperature data, as a function of time, for 30, arbitrary locations in the Northern Hemisphere

stationary distribution (see, for example, [2, 3, 4]). Just to convey a feeling for such analyses, we undertake here a much less rigorous but hopefully illuminating look at some data. It should be cautioned that the application of this theorem to real data is highly nontrivial. Hence, in

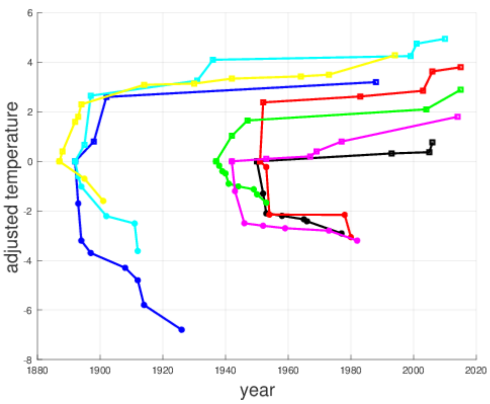

Figure 3: Record values for seven temperature time series, highlighted in Fig. 2. The adjusted temperature subtracts out the first temperature value in the time series. The data is taken from GISS repository. We note that you reach a time in each data set beyond which no new lows occur whereas new highs continue to appear going forward in time. Temperature in degrees C.

what follows, we will be using this exercise merely to give a suggestive outcome.

If the theorem applies to climate data, we expect to wait increasingly long times for each new record temperature value (either high or low) because the probability declines as $1/(t-t_0)$, where the time t of each temperature observation takes the place of the statistical index n, and t_0 is the start of the particular temperature observations. (If the probability distribution were symmetric we would also expect the rates of record highs and lows to be similar).

Figure 1 compares the record highs/lows obtained from a synthetic random time series to the July temperatures measured at the Moscow station, from about 1880 to 2011 [6]. For the random time series, the highs and lows are similarly spaced in time. However, for the Moscow temperature data, one sees many lows occurring at the early times and none after about 1910. By contrast, the record highs are more spaced out in time and continue through the observation period shown. The data suggests that the theorem on records is not fulfilled and that the rate at which record highs or lows occur at time t does not follow $1/(t-t_0)$.

Figures 2 and 3 plot temperature data (from [6]) from 30 locations in the Northern Hemisphere. The locations were chosen at random but were mostly concentrated around temperate zones, simply because these records tended to be longer. The time series are not all the same length and some stations did not report every year. The superposition of the data in Figure 2 would lead you to believe that, over the course of the industrial revolution, a stationary distribution of temperatures is not all that bad a statistical model. In that figure we highlight seven temperature time series, chosen arbitrarily. The records associated with these 7 data are plotted in Figure 3. To facilitate comparison, these seven data sets have been adjusted by subtracting the first temperature in the set (thus the adjusted temperature of any of these time series was 0). Adding more observations to the top set or more observations to the bottom set does not change the impression that, with time, more high records will occur than low records (the low records stop occurring). Another test would be to compute the expectation of the number of records to see if it is logarithmic, but doing so requires either longer data sets or a larger collection of data sets, such as the combined readings of all stations in the United States.

The key observation is that the record highs and the record lows do not obey the $1/t$ dependence. Hence, these temperature records must not be samples from a stationary process.

Wergen and Krug [3, 7, 8] and others, have taken this line of research much further, to include correlations, a multiplicity of distributions, and consideration of spatial dependence. They have also found that removing a trend in the data makes the theorem more likely to be consistent with the statistics of temperature data. The values obtained for the trend, using this analysis, are consistent with estimates of a rate of increase in the global mean temperature of about 0.7°C in the land/ocean temperature over the last century, roughly ten times faster than the average rate of ice-age-recovery warming (see NOAA web site; also see https://globalclimate.ucr.edu/resources.html for educational material on this topic).

In summary, the data suggests that Earth's climate is a non-stationary process. This is something climate scientists would find consistent with what we know about climate. Hence, it is not likely that the temperature extremes that we experience today are rare events, but rather, the result of a changing climate. The findings of this line of inquiry, using much more technical assumptions and allowing for correlations and for a multiplicity of probability distributions, indicates that climate has been severely biased upward during the Industrial Era. The use of this theorem to estimate the return time of record high temperatures would seriously underestimate the occurrence of historical highs, and overestimate historical lows.

Data and models indicate that the global mean temperature of the Earth is increasing, since the end of the 19th century [9]. With a changing climate, we have observed changing weather. The speed at which climate is changing is alarming since it is comparable to, or shorter than, the typical relaxation times of the system (land, ocean, and atmosphere). There are sources for change, both natural and anthropogenic (see [10] and references contained therein). Both of these sources need to be invoked in getting models to agree with data. However, scientists have not been able to find a non-anthropogenic explanation to the observed increase in warm extremes in global temperatures during the Industrial Era (e.g., [11]).

Acknowledgements

The authors would like to thank Barbara Levi who provided invaluable editorial assistance with this article.

References

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[11] M.E. Mann, S.K. Miller, S. Rahmstorf, B.A. Steinman, and M. Tingley. Record temperature streak bears anthropogenic fingerprint. *Geophysics Research Letters*, 44, 2017. doi:10.1002/2017GL074056.

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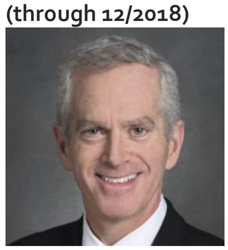

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MARCH MEETING 2018
LOS ANGELES MARCH 5-9

GPC Climate Café

(8:00-10:00 pm, Tuesday March 6)

You are cordially invited to the GPC Climate Café!

The cafe will take place immediately following the **GPC business meeting (Session J39, 5:45-6:45 pm, Tuesday March 6, Rm. 501B).** This is an informal meeting where, over drinks and food, you can meet the March Meeting GPC speakers, as well as fellow GPC and other APS members. We'll discuss climate science, network, and chat with the Executive Committee members about GPC concerns. In keeping with the informal nature of the cafe, we will announce the venue for this year's Climate Cafe at the Tuesday sessions.

All APS members are welcome to attend!

GPC Invited Session: Energy Flows in the Climate System

(Session F16, 11:15 am – 2:15 pm, Tuesday, March 6, Rm. 305)

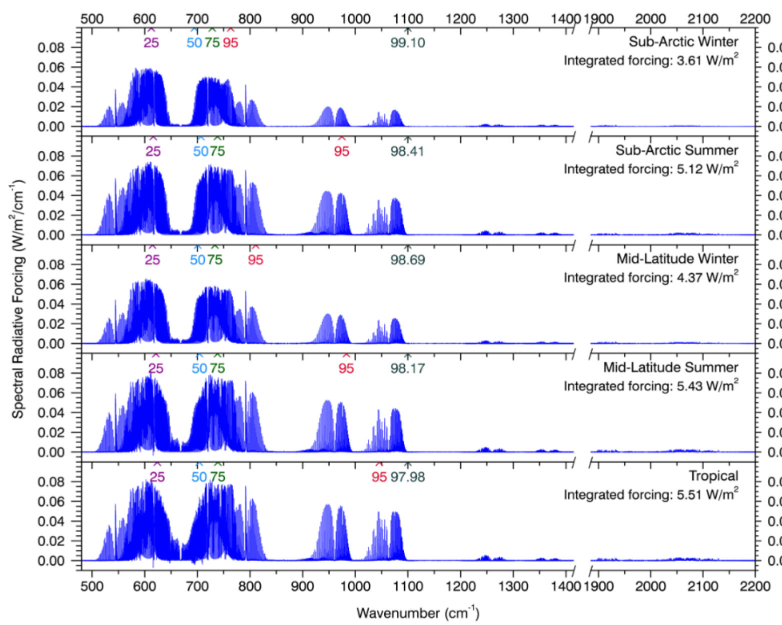
MARTIN MLYNCZAK

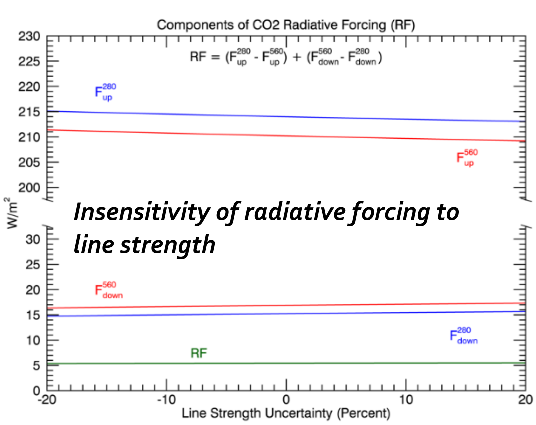
NASA Langley

Title: The Spectroscopic Foundation of Radiative Forcing by Carbon Dioxide

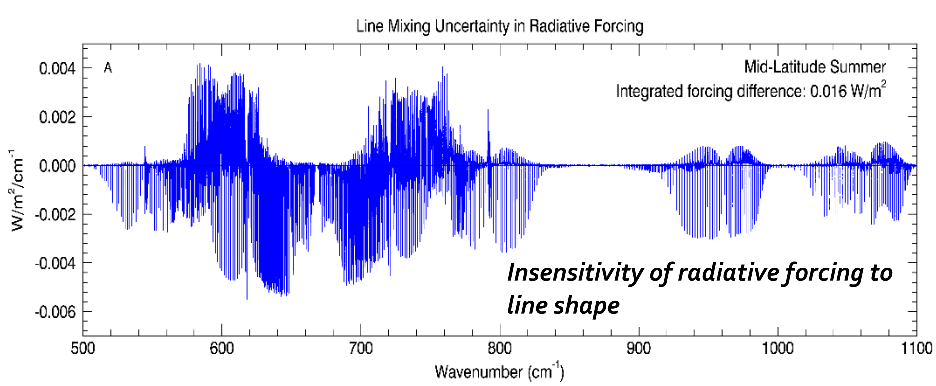
Synopsis: The radiative forcing (RF) of carbon dioxide (CO_2) is the leading contribution to climate change from anthropogenic activities. Calculating CO_2 RF requires detailed knowledge of spectral line parameters for thousands of infrared absorption lines. A reliable spectroscopic characterization of CO_2 forcing is critical to scientific and policy assessments of present climate and climate change. Our results show that CO_2 RF in a variety of atmospheres is remarkably insensitive to known uncertainties in the

Spectrum of radiative forcing by CO_2





Insensitivity of radiative forcing to line strength



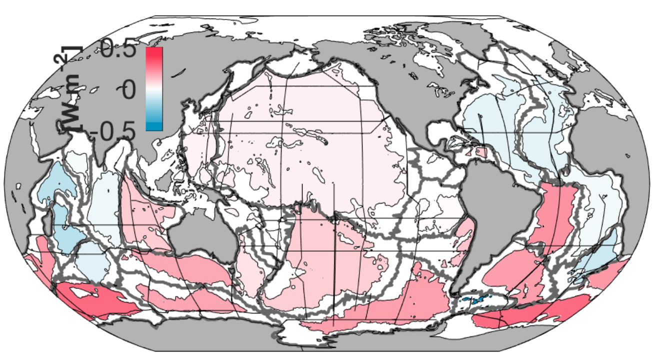
Insensitivity of radiative forcing to line shape

three main CO_2 spectroscopic parameters: the line shapes, line strengths, and line half widths. We specifically examine uncertainty in RF due to line mixing as this process is critical in determining line shapes in the far wings of CO_2 absorption lines. RF computed with a pure Voigt line shape is also examined. Overall, the spectroscopic uncertainty in present-day CO_2 RF is less than 1% (global average), indicating a robust foundation in our understanding of how rising CO_2 warms the climate system.

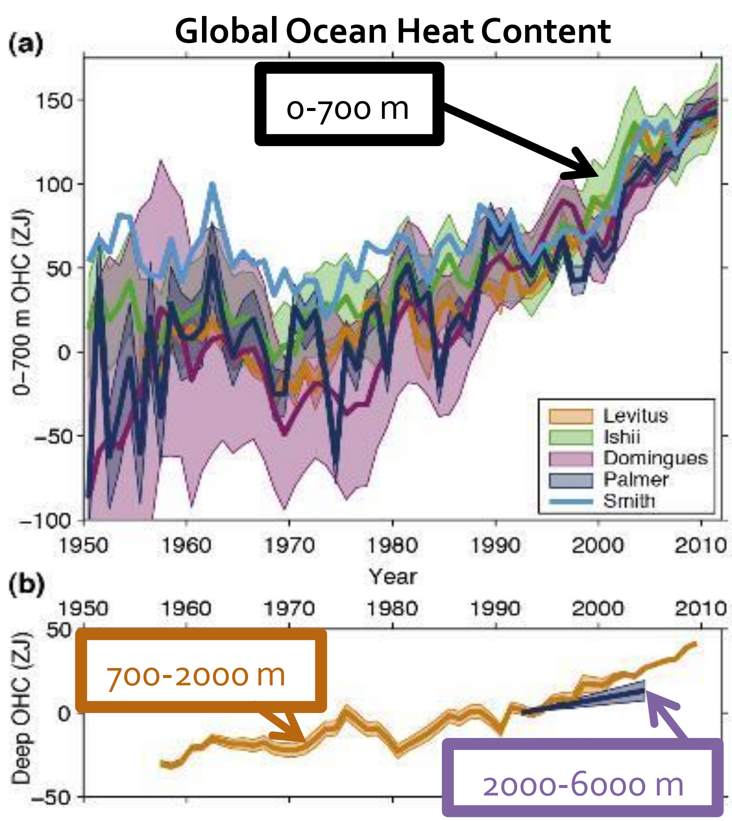
SARAH PURKEY
Scripps Institution of Oceanography
University of California, San Diego

Title: Abyssal Ocean Warming: How the climate system is transferring excess anthropogenic energy into the isolated deep ocean

Synopsis: The Ocean is by far the largest sink for anthropogenic heat introduced into Earth's climate system, currently absorbing over 90% of the global energy imbalance. How efficiently the oceans can continue to drawdown heat in the future will be determined by its ability to export heat from the surface into the interior ocean. Here, we present observational evidence of current Deep Ocean warming rates and the likely physical mechanisms driving this warming. Deep ocean warming trends are determined using all available ship based full depth high-quality deep ocean temperature measurements taken along ocean transects repeated multiple times between 1980 and present. These measurements reveal a global scale multi-decadal abyssal warming signal, with the strongest warming in the Southern Ocean near deep-water formation sites, and extending northward following the deep flow pathways. The integrated global deep warming below 3000 m over the past three decades is equivalent to a heat flux of 0.05 (±0.04) Wm-2 over the entire surface of the earth, or roughly 5% of the global 1 Wm-2 energy imbalance. In addition, this warming produces a 0.1 (±0.08) mm year-1 increase in global average sea level from thermostatic expansion. The vertical distribution of the observed hydrography changes provides strong evidence that the warming is primarily driven by isopycnal heave, rather than an advected change. This could be driven by a decrease in the rate of abyssal ventilation. Transient tracer analysis provides additional evidence that this is indeed a contributing mechanism, suggesting a global scale slowdown of the bottom limb of the meridional overturning circulation.



Ocean observations reveal a deep warming, expressed as a heat flux (color) below 4000 m between 1990 and 2010 using all repeated hydrographic sections (black lines).



The deep warming contributes to the total anthropogenic heat absorbed by the ocean (purple). [Rhein et al. 2013]

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

Left to right: Douglas Kurtze (12/2019), Sharon Sessions (12/2019), Mary Silber (12/2018), Robert Ecke (12/2018), Barbara Levi (12/2020), Isabel McCoy (12/2020), Assigned Council Representative (DFD) Ann Kargozian, Peter Weichman (Newsletter Editor, 12/2018).

KATHARINE RICKE
University of California, San Diego

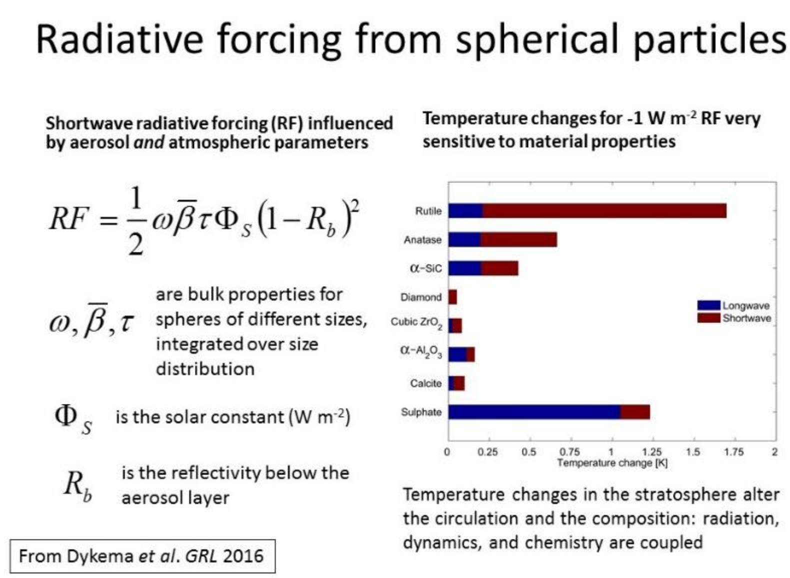
Title: Climate Model-Based Assessments of Regional Responses to Solar Geoengineering

Synopsis: The most straightforward way to avoid the potentially dangerous climate change is to reduce, and eventually eliminate, carbon dioxide emissions from the combustion of fossil fuels. However, given the slow progress on this front, a growing number of proposals have been made for deliberate intervention in the climate through "geoengineering". Several methods have been proposed for deliberately tinkering with the Earth's energy balance to counteract the warming effects of carbon dioxide and other greenhouse gases (GHGs): reflecting an increased fraction of sunlight back into space before it is absorbed by the Earth's surface, increasing the transparency of the Earth's atmosphere to outgoing longwave radiation, or even pumping water from the deep ocean to the surface ocean to cool surface air temperatures. All these proposals imperfectly compensate for the effects of GHGs, altering the intensity of the global hydrological cycle and resulting in shifting regional climate states even when global temperatures are held steady. Here I explore these tradeoffs, as simulated in earth system models.

JOHN DYKEMA
Harvard John A. Paulson School of Engineering and Applied Sciences
Harvard University

Title: Radiative Transfer and Aerosol Scattering

Synopsis: One of the most fundamental energy flows in the climate system is constituted by the radiative input of energy from the sun and the outgoing energy flow from thermal infrared radiation. Aerosols in the atmosphere provide a significant modulation of these energy flows. Depending on the location of the aerosol, its composition, and its physical details (particularly its size), the aerosol may introduce a positive or negative net



perturbation to the balance between these incoming and outgoing radiative flows. This radiative impact of aerosols has been observed to produce a substantial short-term impact on climate in the case of major volcanic eruptions, which have resulted for some well-known instances in a significant global temperature anomaly persisting for more than a year. A quantitative understanding of aerosol perturbations to the climate radiative balance requires a detailed understanding of the processes that govern radiative transfer in the atmosphere. These processes rest on fundamental optical properties, such as the complex refractive index, of the condensed phase materials that constitute aerosols. While laboratory measurements to quantify complex refractive index are routine, the samples used for laboratory measurements may not be representative of atmospheric particulates in important ways. These differences can lead to substantially different quantitative assessments of the radiative perturbations caused by aerosol scattering. This is particularly the case for studies investigating the risks and efficacy of albedo modification by deliberate introduction of aerosols into the atmosphere as a form of climate intervention. This talk will survey relevant aspects of radiative transfer and aerosol scattering and examine their implications in recent research studying hypothetical scenarios of albedo modification.

GPC Program Committee:

Left to right: Michael Mann (Chair), Katie Dagon, Chris Forest, Karen McKinnon

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 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.

RON MILLER

NASA Goddard Institute for Space Studies

Title: Climate Response to Radiative Forcing By (Dust) Aerosols: Energy and Moisture Constraints

Synopsis: The radiative perturbation to climate by aerosols has large regional variations, reflecting the localized sources and short lifetime of aerosols compared to greenhouse gases like carbon dioxide. The climate adjusts to aerosol forcing far beyond regions of high concentration through atmospheric transport of energy and moisture. This combination of local sources and planetary scale adjustment makes it challenging to identify the robust climate response to aerosols that is consistent among different climate models and is expected to appear in future model simulations. Constraints from the atmospheric budgets of energy and moisture help to identify robust aspects of both the global and regional climate response. The presentation will illustrate some of these constraints for the example of dust aerosols that are created by soil erosion and make a leading contribution to the emitted aerosol mass.

Figures A and B illustrate that absorption of shortwave radiation by dust particles is not well-constrained by measurements, so modelers use a range of values that results in a range of estimates for direct radiative forcing by dust. Forcing according to three estimates of absorption is shown in Fig. A. As the prescribed absorption of shortwave radiation by dust particles increases, more sunlight is absorbed within the dust layer, causing the surface to dim (corresponding to more negative forcing: see the bottom right panel). In general, greater absorption causes more warming at the surface (left side of Fig. B). This is because shortwave heating of the dust layer causes the atmosphere to heat up and emit more longwave radiation to space in compensation. Because of vertical mixing of energy by convection, this warming aloft within the dust layer causes warming at the surface (bottom left panel). The Sahel appears to be an exception in this panel with surface cooling. However, this cooling is due to increased precipitation resulting from dust in a rain-limited region that allows a shift from cooling of the surface sensible heating toward evaporation. Because the latter is a more efficient form of energy transfer, an increase in evaporation

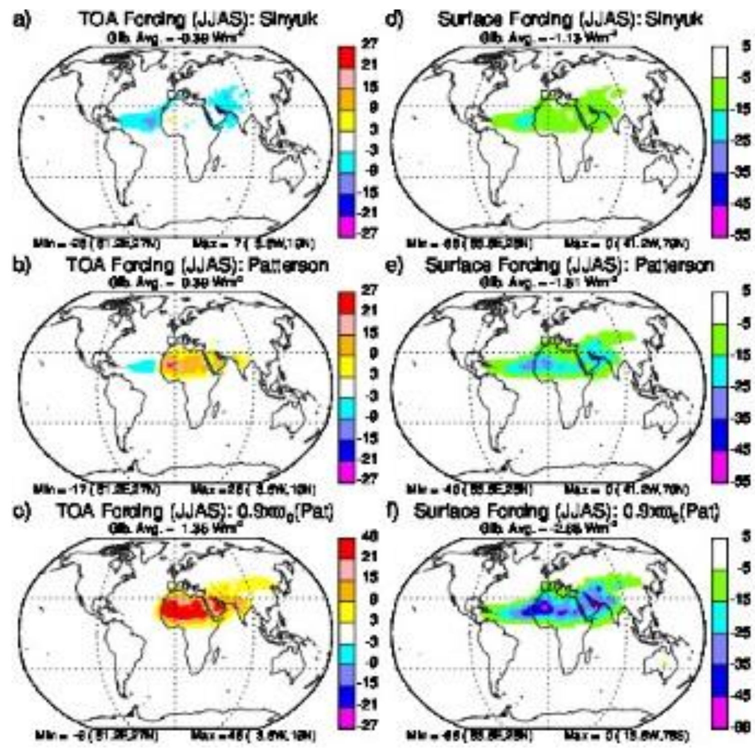


Fig. A: *Forcing calculated at the top of the atmosphere and the surface during Northern Hemisphere (NH) summer with a prescribed dust distribution. In each of the three rows, shortwave absorption is prescribed using a different estimate from the literature. The forcing represents an average during the initial 5 years of a simulation whose climate is perturbed by dust. Ocean temperature evolves according to a mixed-layer model. The forcing equals the contrast between radiative fluxes calculated with and without dust.*

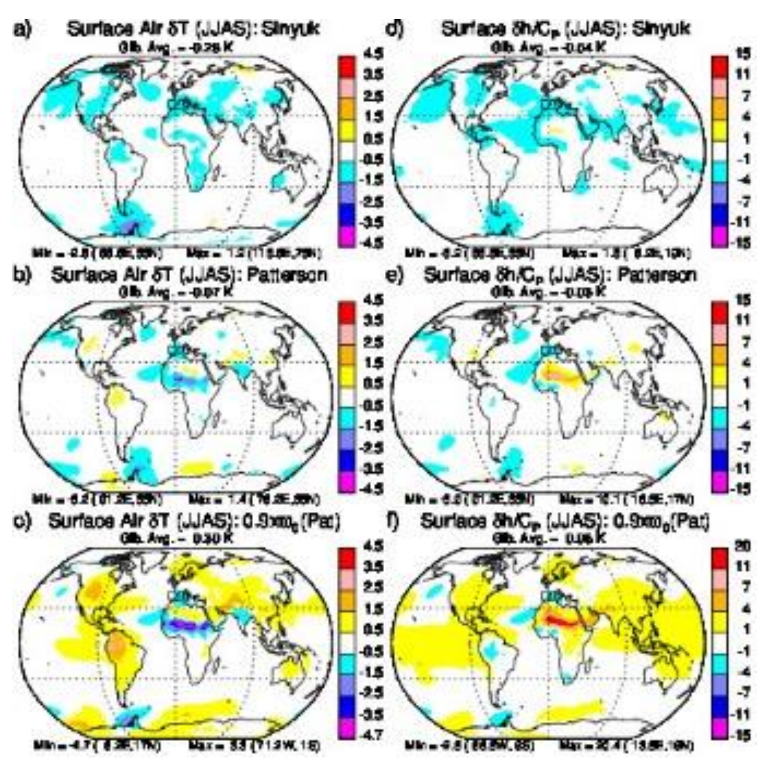


Fig. B: *Anomalous surface air temperature (left) and moist static energy (right) (divided by C_p) in response to the forcing shown in Fig. A.*

allows surface cooling. The signature of warming aloft is in the surface moist static energy (right side of the figure), which increases with prescribed particle absorption, even though the surface is getting cooler (left side of the figure). The difference between the cooler temperature and the greater value of moist static energy indicates greater moisture at the surface due to dust radiative forcing. More generally, this shows that to understand changes in surface temperature by dust, radiative forcing and the response must be considered for the entire column, due to vertical transfer of energy by convection.

Reference: R. L. Miller, P. Knippertz, C. Pérez García-Pando, J. P. Perlwitz, and I. Tegen, "Impact of dust radiative forcing upon climate," in *Mineral Dust — A Key Player in the Earth System*, edited by P. Knippertz and J.-B. W. Stuut, chap. 13, pp. 327–357, Springer Netherlands, doi:10.1007/978-94-017-8978-3 13 (2014).

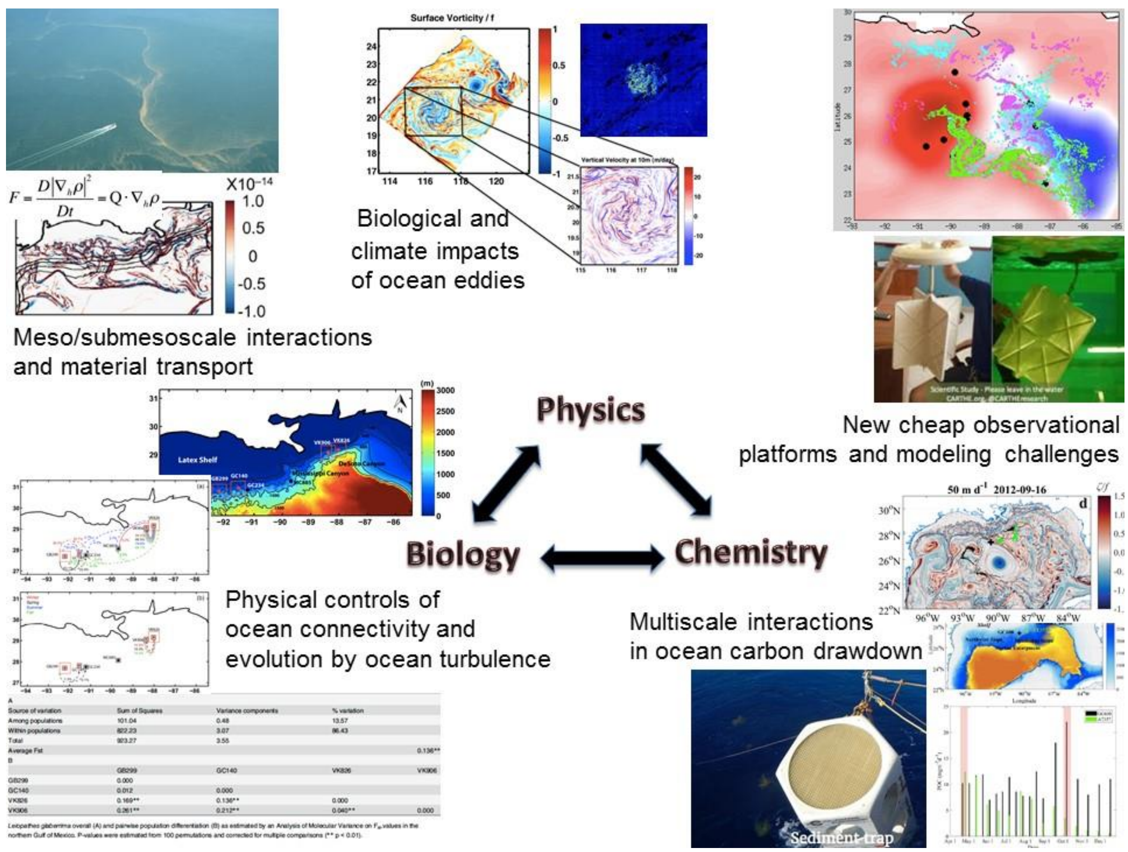
GPC Focus Session: Multi-Scale Flows and Pathways in the Climate System

(Session H46, 2:30 – 5:30 pm, Tuesday, March 6, Room 506)

Invited talks:

ANNALISA BRACCO
School of Earth and Atmospheric Sciences
Georgia Tech

Title: Multi-Scale Flows and Pathways in the Gulf of Mexico and South China Sea: implications of ocean submesoscale turbulence for oil dispersion, coral evolution and carbon uptake



Synopsis: In the ocean, forcing acts at planetary scales and dissipation at microscales. In between there are the mesoscales, with characteristics akin to nearly two-dimensional, quasi-geostrophically, balanced turbulence. The dynamical structures typical of the mesoscales are eddies and fronts. They extend from few tens to hundreds of kilometers, and act as weather systems of the ocean.

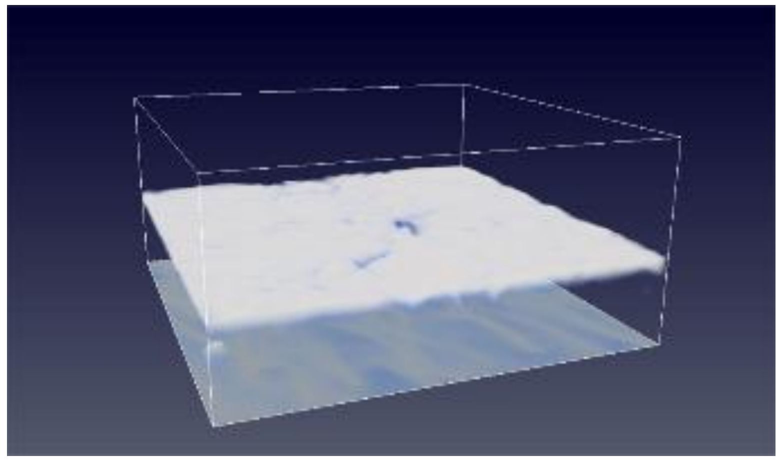
At the ocean boundary layers, near the surface and at the bottom, unbalanced, submesoscale flow structures may appear in the form of vorticity filaments, density fronts or coherent vortices, with typical scales of hundreds of meters to a few kilometers, and a lifespan of several hours to a few days. These submesoscale circulations provide a pathway for energy transfer towards smaller scales, are likely to contribute to the overall overturning budget, and impact lateral and diapycnal mixing.

Here I present an overview of recent studies of physical and biogeochemical interactions across mesoscale and submesoscale flows focusing on the Gulf of Mexico and South China Sea. I will describe the physical mechanisms responsible for the patterns of oil dispersion at the ocean surface and near the bottom using models and observations from the aftermath of the 2010 Deepwater Horizon oil spill, and will provide examples of how mesoscale and submesoscale circulations impact the dispersion of tracers, from carbon to cold-water coral larvae.

TAPIO SCHNEIDER
California Institute of Technology

Title: Multiscale processes and instabilities in Earth's clouds: Why we must and how we can make progress in modeling them

Synopsis: How Earth's low clouds respond to climate change is the most important unsolved problem in the physical climate sciences. It is the source of the largest uncertainties in climate projections. The reason is the multiscale nature of clouds: scales from the micrometers or droplet formation, to the meters of turbulent cloud dynamics, to the thousands of kilometers of large-scale atmospheric circulations are intricately coupled in clouds. Explicitly resolving this large a range of scales in numerical simulations will remain out of reach for the foreseeable future. Here I show that the interplay of radiative and dynamical processes can give rise to instabilitites in stratocumulus clouds, which have the potential to dramatically alter climate. Such instabilities are not captured by current climate models because they inadequately represent the multiscale physics of clouds. I lay out a blueprint for climate models that can overcome these difficulties and provide more accurate projections of climate changes.



Stratocumulus clouds from a large-eddy simulation

Contributed talks:

Juan Restrepo, Shankar Venkataramani, Clint Dawson	Nearshore Sticky Waters
Kathleen Schiro, J David Neelin, Fiaz Ahmed	Deep-inflow approach to mesoscale-organized and unorganized deep convection and the likely role of coherent structures
Jesse Norris, Gang Chen, J. David Neelin	Understanding physical mechanisms associated with enhancement/reduction of extreme precipitation in a warming climate
William Collins, Daniel Feldman, Chaincy Kuo, Newton Nguyen	Large Regional Shortwave Forcing by Anthropogenic Methane Informed by Jovian Observations
David Raymond, Sharon Sessions	A Rational Approach to Cumulus Parameterization
Sharon Sessions, K Ryder Fox, Stipo Sentic, Patrick Haertel, David Raymond	Evaluating Lagrangian Model Simulations of the Madden-Julian Oscillation with Metrics for Balanced Dynamics
John Marston, Joseph Skitka, Baylor Fox-Kemper	Reduced-Order Quasilinear Dynamics of Ocean Surface Boundary-Layer Flows
Pedram Hassanzadeh , Ashesh Chattopadhyay	Reduced-Order Models for the Large-Scale Atmospheric Turbulence
Valerio Lucarini , Stephane Vannitsem	Statistical and dynamical properties of covariant lyapunov vectors in a coupled atmosphere-ocean model—multiscale effects and geometric degeneracy

Upcoming Events and Other Links of Interest

1. KITP Program on "Planetary Boundary Layers in Atmospheres, Oceans, and Ice on Earth and Moons", UC Santa Barbara, CA, April 2-June 22, 2018. The application deadline for this program has already passed, but registration for the associated five-day conference, Frontiers in Oceanic, Atmospheric, and Cryospheric Boundary Layers, May 21-25, 2018, is still open.
2. The University of Chicago, Department of Geophysical Sciences is hosting Rossbypalooza-2018. It is a two-week long student-led summer school bringing together graduate students and postdocs from atmospheric, oceanic and planetary sciences. The topic for this year is "Understanding climate through simple models". The school will run June 11 – 23, 2018. The application deadline is April 10th, 2018. Some travel funding is available.