Written Testimony of Dr. Noah S. Diffenbaugh

Hearing on "The Science Behind Impacts of the Climate Crisis"
March 12, 2021

Congress of the United States
House of Representatives
Committee on Science, Space, and Technology

Thank you Chairwoman Johnson, Ranking Member Lucas, and the members of the Committee for the invitation to testify.

My name is Noah S. Diffenbaugh. I am the Kara J Foundation Professor in the School of Earth, Energy and Environmental Sciences at Stanford University, and the Kimmelman Family Senior Fellow at Stanford's Woods Institute for the Environment. I am testifying before the committee in my personal capacity, not on behalf of Stanford University.

I study Earth's climate, including how changes in regional and local conditions – such as extreme weather events – affect people and ecosystems. I received my Ph.D. degree from the University of California–Santa Cruz in 2003. I am an elected Fellow of the American Geophysical Union (AGU), the largest scientific society of Earth and space sciences in the world. For more than a decade, I have served as an Editor of peer-review journals published by the AGU, including a four-year term as Editor-in-Chief of *Geophysical Research Letters*, one of the leading peer-review journals publishing climate science research. I have been a lead author for a number of scientific assessments, including the IPCC Fifth Assessment Report and the California Climate-Safe Infrastructure Working Group.

The subject of this hearing of the Committee on Science, Space, and Technology is "The Science Behind Impacts of the Climate Crisis". I will focus my remarks on the topics noted in your invitation letter, including recent improvements in our understanding of how climate change is contributing to increased risk from extreme events such as wildfire, drought, and severe storms; the disproportionate impacts on vulnerable communities; the importance of quantifying climate impacts and risk for achieving Paris Agreement targets; and the implications for mitigation and adaptation solutions.

The brief summary is that:

(i) Extreme events are increasing in frequency and severity, including those that are unprecedented in our historical experience;

(ii) We are not adapted to these changes, meaning that global warming is already impacting people and ecosystems in the United States and around the world, including through financial costs, loss of life and destruction of habitat, with disproportionate impacts on poor and marginalized communities;

(iii) The greater the global warming that occurs in the future, the more these risks will intensify, including non-linear intensification of many impacts;

(iv) As a result, achieving the Paris Agreement global warming goals will reduce the impacts that we experience, including reducing the financial costs of further climate change;

(v) However, even if the Paris Agreement global warming goals are achieved, there will still be more climate change than has already occurred, and hence adaptation will be necessary to avoid further impacts; and

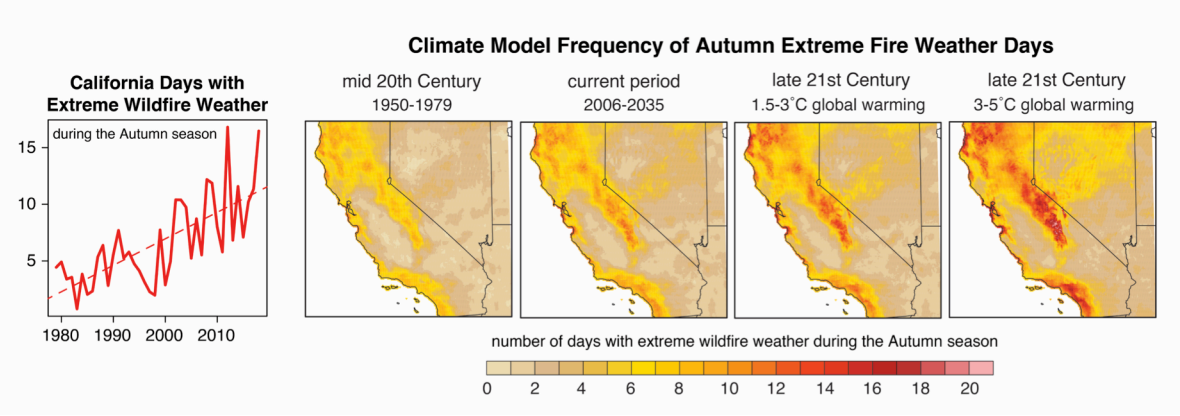
(vi) Research is needed to successfully develop and deploy the mitigation and adaptation solutions that are necessary to curb the intensification of climate extremes and the associated impacts on people and ecosystems.

We now have ample evidence that global warming has increased the risk of many kinds of climate and weather extremes (e.g., [*NAS*, 2016]), including extreme heat, heavy rainfall, storm-surge flooding, severe drought, and extreme wildfire conditions. And by increasing the frequency of extremes in multiple locations, climate change is increasing the odds that multiple extremes happen simultaneously, which is increasing the odds that our infrastructure and disaster management systems are stretched past their limit.

The last year has brought these accelerating risks into stark relief. While it has felt like an unrelenting string of bad luck, this is the world that global warming has created: a world in which more extreme conditions happen simultaneously, both on top of each other in a given location, and at the same time in different parts of the country and the world. And when an additional, unrelated disruption occurs – like a global respiratory pandemic – it is now much more likely to coincide with extreme climate conditions, ratcheting up the stress on our disaster response systems.

This is exactly what happened in California this summer: a dry winter was followed by a very warm spring that caused rapid snowmelt, which was followed by a record summer heat wave, leading to record- or near-record fuel loads. The heat wave was unusually humid, which led to a very unusual lightning siege, which caused hundreds of wildfires. Having so many fires burning in such flammable conditions simultaneously stretched the firefighting resources beyond their limit, resulting in more than 1 million acres burned in less than two weeks, and more than 4 million acres burned for the season, including five of the six largest wildfires in California's recorded history.

There are now multiple lines of evidence that global warming has increased wildfire

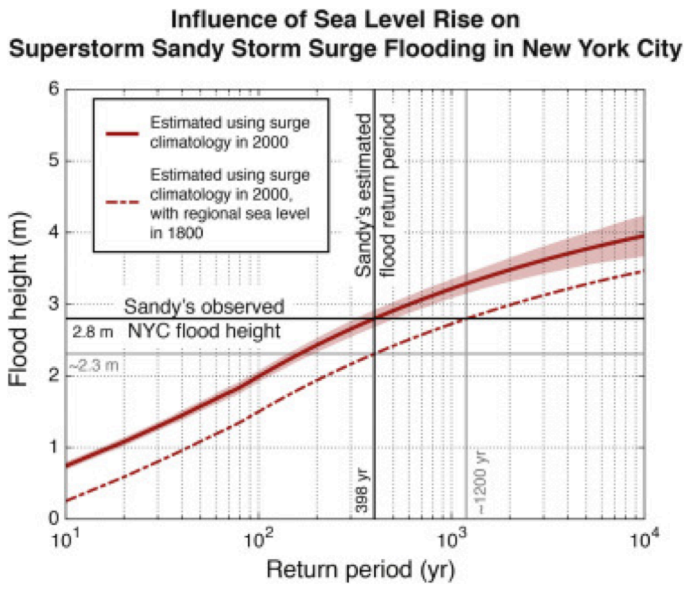


Adapted from Goss et al. (2020)

risk in California and the American West. Previous work has shown that the annual area burned has increased approximately 10-fold in the West over the past 4 decades [*Duffy et al.*, 2019], and that rising temperatures have increased fuel loads, contributing around half of the increase in area burned [*Abatzoglou and Williams*, 2016]. This effect has also been prominent in California [*Williams et al.*, 2019]. In addition, this summer my colleagues and I published a paper showing that the frequency of extreme wildfire weather has more than doubled in California during the autumn season [*Goss et al.*, 2020]. Critically, we find that global warming is increasing the risk that periods of extreme wildfire weather overlap across far-flung regions of the state.

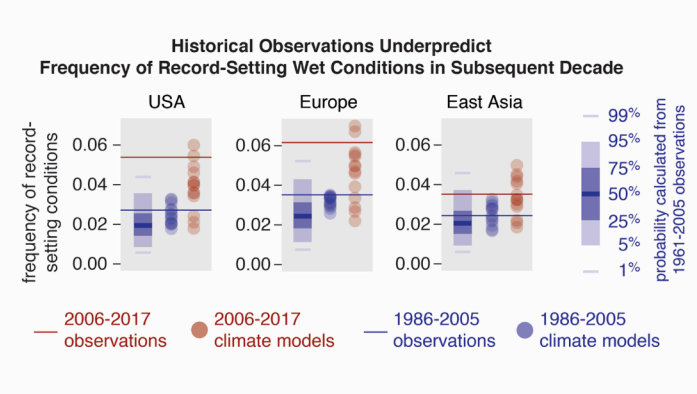
Given limited resources, many of our disaster response systems are designed to pre-stage resources in areas that are likely to experience disasters, meaning that those systems become stressed – sometimes beyond the breaking point – when multiple events occur simultaneously. And because the increasing co-occurrence of extreme events is a global phenomenon, it is creating novel challenges for our globalized economy, including our globalized risk management systems. This was made starkly clear in late 2019, when autumn wildfires in California overlapped with spring fires in Australia, stressing the limited aircraft and other resources that normally move between the hemispheres during the seasonal transition. In addition, that same combination of warm and dry conditions that increases wildfire risk has other impacts, including on our food system. Several studies, including from my research group, have shown that "bread basket" regions that are responsible for the majority of the world's grain production are now much more likely to experience adverse growing conditions in the same year, compared with just a few decades ago [*Sarhadi et al.*, 2018].

Recent hurricane seasons have put similar stresses on our disaster preparation and response systems. In 2017, Hurricane Harvey's record rainfall produced one of the most expensive disasters in U.S. history. In addition, with multiple hurricanes striking the U.S. and Caribbean, there were too many landfalls for ships to transport supplies to all affected areas fast enough. The 2020 Atlantic hurricane season was even more active, with more named storms than any previous year in recorded history, and some areas – including Louisiana and Guatemala – experiencing multiple landfalls in rapid succession.



Swain et al. (2020) [adapted from Lin et al., 2016]

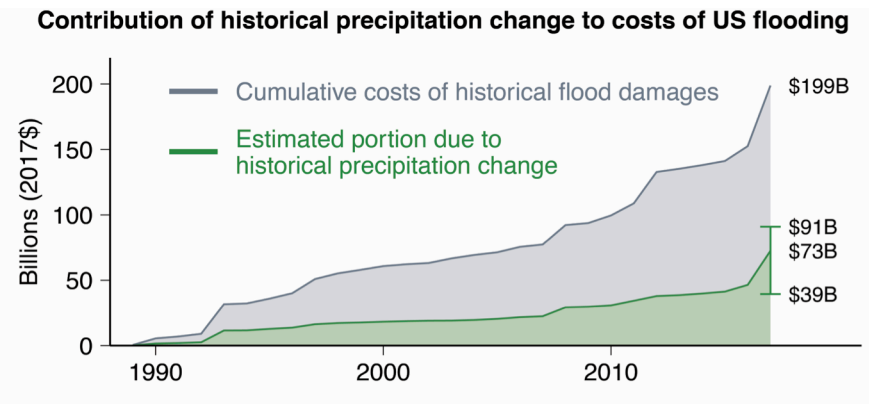
While there is still uncertainty about exactly how global warming influences the number of hurricanes, we know that the warming of the ocean increases the energy available for storms (e.g., [*Emanuel*, 2005; *Trenberth et al.*, 2018]). We also know that the warming of the atmosphere has increased the likelihood that hurricanes produce extreme precipitation, like occurred during Hurricane Harvey (e.g. [*Emanuel*, 2017; *Trenberth et al.*, 2018]) and Hurricane Florence in 2018 [*Reed et al.*, 2020]. And we know that the sea level rise that has already occurred has increased the risk of extreme storm surge flooding, like what occurred in New York City during Superstorm Sandy in 2012 [*Lin et al.*, 2016], and this season along the Gulf Coast when storms rapidly intensified before making landfall.



Adapted from Diffenbaugh (2020)

Disasters are ultimately a function of the difference between the magnitude of the hazard and the level of preparation [*IPCC*, 2012]. We have now crossed the threshold where the climate envelope for which so many of our systems have been designed, built and operated is exceeded with increasing frequency [*Diffenbaugh*, 2020] – from our disaster management systems, to our electrical grids, to our water and transportation infrastructure. Crossing that threshold means that we're now living in a world where our status quo risk management systems are inadequate. And as a consequence, in the absence of adaptation, we can expect more big disasters to happen in more places more often, with poor and marginalized communities experiencing the greatest vulnerability.

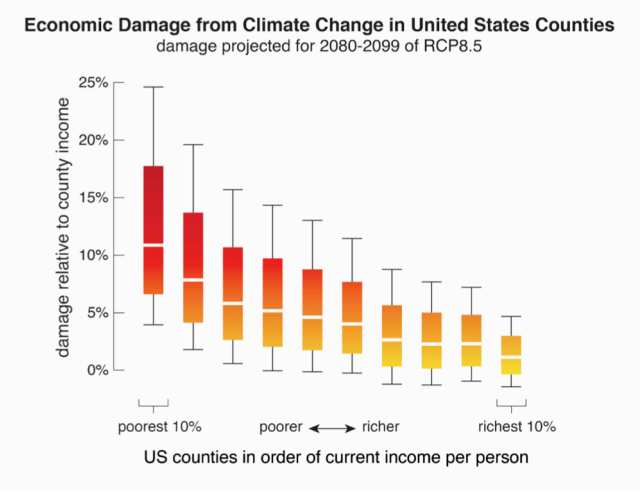
Recent research shows that this is already costing us financially. In January, my research group published a paper documenting that historical changes in precipitation – particularly intensification of the extreme wet events – account for approximately one third of the cumulative flood damages in the U.S. over the past three decades [*Davenport et al.*, 2021]. Using similar research methods to analyze the impact of temperature variations on aggregate economic activity, colleagues have estimated that historical warming has cost the U.S. economy approximately 5 trillion dollars within the past two decades [*Burke and Tanutama*, 2019]. These economic impacts are likely to accelerate in the U.S. at higher levels of global warming, with the poorest counties being harmed



Adapted from Davenport et al. (2021)

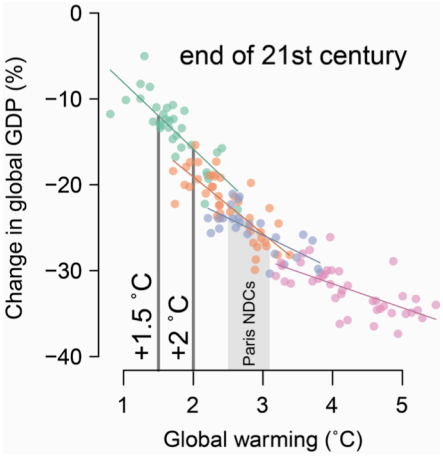
around twice as much as the richest counties, exacerbating existing economic inequality [*Hsiang et al.*, 2017; *Duffy et al.*, 2019].

These impacts on economic inequality are not confined to the United States. For example, my collaborator and I have documented that country-level economic inequality is approximately 25% greater today than in a counterfactual world in which historical global warming had not occurred [*Diffenbaugh and Burke*, 2019]. The strongest contributor has been the accumulated effects of diminished GDP growth in countries that are already warm, including our neighbors in Central and South America.



Duffy et al. (2019) [adapted from Hsiang et al., 2017]

Fortunately, there are options. Over the long-term, achieving the Paris Agreement goal of holding global warming below 2˚C will substantially curb the intensification of these impacts. For example, we have evidence that the frequency of extreme conditions such as extreme heat, extreme precipitation, extreme storm surge flooding and extreme wildfire weather will increase less at 1.5 or 2˚C than at 3 or 4˚C (e.g., [*IPCC*, 2014; *Diffenbaugh et al.*, 2018; *Sarhadi et al.*, 2018; *Allen et al.*, 2019; *Goss et al.*, 2020; *Davenport et al.*, 2021]). Likewise, in addition to substantially reducing the level of global economic damages [*Burke et al.*, 2018], the Paris Agreement goals are also very likely to reduce the magnitude of economic damage in the poorest countries [*Burke et al.*, 2018], and in the poorest U.S. counties (e.g., as in [*Burke and Tanutama*, 2019; *Duffy et al.*, 2019]).



Adapted from Burke et al. (2018)

Therefore, in terms of reducing the risks of high-impact climate change, there is substantial benefit to achieving the Paris Agreement goals. Further, in addition to curbing the severity of climate change, many of the mechanisms that we have for reducing emissions can also increase resilience to climate stresses by providing critical energy resources to communities whose development and well-being have been hampered by energy poverty and/or pollution, and by increasing the resilience of the energy system overall. We also have opportunities to increase resilience by investing in marginalized communities,

which we know are both more vulnerable and more exposed to climate extremes. And carefully considering how and where we build – and how we preserve and manage ecosystems – as we provide for growing needs for fair and equitable housing and livelihoods is important for managing a range of climate risks, including wildfires in the West, hurricanes in the Southeast, and floods in the Midwest. And, in addition to all of these "win-win" opportunities, avoiding frequent, widespread, devastating disasters will require re-designing our infrastructure and disaster risk management around the growing likelihood that multiple unprecedented events occur simultaneously – locally, regionally and around the world.

How can we do this? In your invitation letter, you asked me to "Please include any research gaps or recommendations of additional investments in climate science that the Committee should address." Given the unprecedented climate events that we are already facing, and the high confidence that further warming will lead to further intensification of those unprecedented conditions, the reality is that successfully managing the risks of climate change – including both the unequal impacts across society and the costs born by all Americans – will require acceleration of both mitigation and adaptation actions. We have sufficient understanding to begin that acceleration.

In addition, in order to achieve the level of mitigation that is necessary to stabilize the climate system and the level of adaptation that is necessary to respond to the further climate change that will occur, additional research is needed. In particular, a cohesive research agenda that integrates mitigation and adaptation in support of a climate-resilient nation would include the following six themes:

(i) improved observational and modeling capacity for predicting extreme events across weekly, seasonal and decadal timescales;

(ii) R&D for both the technologies and large-scale deployment necessary to transition to a secure, reliable, equitable net-zero-emissions energy system;

(iii) improved understanding of the climate impacts of "overshooting" the Paris Agreement goals, as well as the options for – and risks of – negative emissions technologies;

(iv) R&D for development, implementation and deployment of adaptation approaches across a variety of geographic, climatic and socioeconomic contexts;

(v) information, methodologies and decision support for updating the design guidelines and operational practices for our local, state and national infrastructure to be resilient in the current and future climate; and

(vi) improved understanding of how to generate synergies between mitigation, adaptation and other policy priorities such as economic growth, job creation, environmental conservation, and economic, racial and environmental justice.

In addition, the pandemic has revealed many limitations in our real-time observing systems, including critical Earth system elements such as real-time measurements of greenhouse gas emissions and the vertical structure of air pollutants in the atmosphere, as well as real-time measurements of human elements that are critical for the Earth system, such as real-time measurements of economic activity and its consequences [*Diffenbaugh et al.*, 2020].

As recent events have made painfully clear, climate change is already impacting us. Decades of objective, thorough, systematic research show that we can expect those impacts to intensify as long as global warming continues. Addressing this challenge will require both mitigation and adaptation, including the research necessary to make each of those possible.

I applaud the Committee for working on these critical issues, and thank you for the opportunity to provide this testimony. I look forward to discussing any questions that you may have.

Curriculum Vitae | Noah S. Diffenbaugh | March 7, 2021

1. ACADEMIC HISTORY

Colleges and universities attended

Ph.D., Earth Sciences, University of California, Santa Cruz	2000 – 2003
M.S., Earth Systems, Stanford University	1996 – 1997
B.S., Earth Systems, Stanford University	1992 – 1997

Scholarships and honors

ARCS Foundation Scholar	2002 – 2003
University of California Regents Fellowship	2000 – 2001

Post-doctoral and residency training

Postgraduate Research Earth Scientist, University of California, Santa Cruz	2003 – 2004

Other study and research opportunities

Short Term Visitor, Abdus Salam International Centre for Theoretical Physics	2006 – 2010

2. EMPLOYMENT HISTORY

Kara J Foundation Professor, School of Earth, Energy and Environmental Sciences	2017 –
Kimmelman Family Senior Fellow, Woods Institute for the Environment	2017 –
Professor, Earth System Science, Stanford University	2016 –
Senior Fellow, Woods Institute for the Environment, Stanford University	2013 –
Associate Professor, (Environmental) Earth System Science, Stanford University	2013 – 2016
Center Fellow, Woods Institute for the Environment, Stanford University	2009 – 2013
Assistant Professor, Environmental Earth System Science, Stanford University	2009 – 2013
Associate Professor of Earth and Atmospheric Sciences, Purdue University	2008 – 2009
Assistant Professor of Earth and Atmospheric Sciences, Purdue University	2004 – 2008
Postgraduate Research Earth Scientist, University of California, Santa Cruz	2003 – 2004
Graduate Research and Teaching Assistant, University of California, Santa Cruz	2000 – 2003
Science Teacher, Volleyball Coach and Athletic Director, Mt. Madonna School	1997 – 2000

3. PUBLIC AND PROFESSIONAL SERVICE

Selected professional appointments

Guest Editor, *Proceedings of the National Academy of Sciences*	
Editor, *Earth's Future*	2020 –
Editor-in-Chief, *Geophysical Research Letters*	2015 – 2018
Editor, *Geophysical Research Letters*	2009 – 2019
Member, Manabe Award Selection Committee, American Meteorological Society	2020 –
Member, Holton Award Selection Committee, American Geophysical Union	2019 –
Member, State of California AB 2800 Climate Safe Infrastructure Working Group	2017 – 2018
Lead Author, Working Group II, Intergovernmental Panel on Climate Change	2010 – 2014
Member, National Academy of Sciences Ad Hoc Committee on Effects of Provisions in the Internal Revenue Code on Greenhouse Gas Emissions	2011 – 2013
Member, "What We Know" Panel on Climate Change, AAAS	2013 – 2014
Science Advisory Board, Climate Research Program, Lawrence Livermore National Lab	2016 – 2018
Science Advisory Board, Climate Change Science Institute, Oak Ridge National Lab	2012 – 2015
Members Nominating Committee, University Corporation for Atmospheric Research	2017 – 2019
Members Nominating Committee, University Corporation for Atmospheric Research	2015
Governance Task Group, University Corporation for Atmospheric Research	2014 – 2017
Member Representative, University Corporation for Atmospheric Research	2010 –
Executive Committee, Atmospheric Sciences Section, American Geophysical Union	2008 – 2012

Member, Terrestrial Ecosystems and Climate Policy Working Group, National Center for Ecological Analysis and Synthesis	2008 – 2010
Interim Director, Purdue Climate Change Research Center	2008 – 2009
Editorial Advisory Board, *Eos*, American Geophysical Union	2008 – 2009
Co-Guest Editor, Special Issue, *Palaeogeography, Palaeoclimatology, Palaeoecology 236*(1-2), 1-168, 2006	2004 – 2006

Selected university service (at Stanford University)

Member, University Budget Group, Stanford University	2019 – 2024
Co-Chair, President's committee on Sustainability Initiative organizational structure	2019 – 2020
Member, Faculty Senate	2018 – 2019
Member, Academic Council Committee on Graduate Studies	2018 – 2020
Earth Council, School of Earth, Energy and Environmental Science	2016 –
Member, Faculty Advisory Committee on Research Computing	2016 – 2018
Faculty Moderator, Three Books Program	2016 – 2017
Director of Graduate Studies, Department of Earth System Science	2015 – 2019
Member, Undergraduate Advisory Council (UGAC)	2014 – 2018
Member, Faculty Advisory Board, Introductory Seminar Program	2013 – 2016
Resident Fellow, West Florence Moore Hall	2013 – 2014
Faculty Director, Goldman Honors Program	2012 – 2015
Affiliated Faculty, Precourt Institute for Energy	2011 –
Affiliated Faculty, Emmett Interdisciplinary Program (E-IPER)	2009 –

Selected government outreach

Congressional Testimony, Hearing on Creating a Climate Resilient America, U.S. House of Representatives, May 23, 2019, Washington, D.C.

Briefings for US Congressional Offices, May 23, 2019, Washington, DC

Briefings for US Congressional Offices, May 1, 2017, Washington, DC

Briefing for State Legislators and Staffers, The State Capitol, January 25, 2017, Sacramento, CA.

First Hearing of the California State Assembly Select Committee on Water Consumption and Alternative Sources, November 17, 2015, Sacramento, CA.

Congressional Briefing for U.S. Representative Michael Honda, Ranking Member of Appropriations Subcommittee on Commerce, Science and Justice, September 17, 2015, Washington, D.C.

Briefings for U.S. Rep. Anna Eshoo and Congressional staffers, September 17, 2015, Washington, D.C.

Briefing for California State Assemblymember Richard Gordon, May 8, 2015, Los Altos, CA.

Briefings for Sec. John Laird (Secretary of Natural Resources, State of California), staffers for California Department of Water Resources, and staffers for Gov. Jerry Brown, and the State of California Interagency Drought Task Force, March 26, 2015, Sacramento, CA.

Briefings for Congressional staffers and U.S. State Department staff, May 13, 2014, Washington, D.C.

Congressional Testimony, Forum on Climate Change, Safe Climate Caucus, U.S. House of Representatives, September 17, 2013, Washington, D.C.

Climate Science Day on Capitol Hill, Geological Society of America, February 26-27, 2013, Washington, D.C.

Climate Science Day on Capitol Hill, American Association for the Advancement of Science, January 31-February 1, 2012, Washington, D.C.

Climate Science Day on Capitol Hill, American Geophysical Union, February 16-17, 2011, Washington, D.C.

DOE Climate Change Science: Focus Group, July 27-28, 2009, Washington, D.C.

Briefing for Indiana Congressional Delegation, April 27, 2009, Washington, D.C.

Briefing for Indiana Governor Mitch Daniels, April 20, 2009, Indianapolis, IN.

Contributing Author, CCSP Synthesis and Assessment Product 3.4, Abrupt Climate Change: *Hydrologic Variability and Change* (Chapter 3), 2008.

Coordinating Lead Author, *Climate Change in Indiana: Initial Analyses of Impacts and Opportunities*, an analysis of S.2191 prepared at the request of U.S. Senator Richard Lugar's office, 2008.

Contributor, Agency Technical Working Group, Potential Effects of Climate Change on New Mexico, State of New Mexico, 2006.

Keynote Lecture, Legislative Agricultural Chairs Summit '07, January 26-28, 2007, Washington, D.C.

Selected recent public outreach (last 3 years)

Weekly queries from local, national and international media outlets (print, radio, television and internet). Coverage includes *New York Times*, *Washington Post*, *Los Angeles Times*, *San Francisco Chronicle, The Associated Press, The Economist* magazine*, Scientific American* magazine, *ABC News* television, *NBC News* television, *CNN* television*,* and *National Public Radio*.

Seminar, Stanford Parents' Club, April 13, 2021 (virtual).

Seminar, Earth System Science Interdisciplinary Center (ESSIC), University of Maryland, April 12, 2021 (virtual).

Seminar, Department of Wildlife Ecology and Conservation at the University of Florida, March 8, 2021 (virtual).

Keynote, Workshop of the Inter-Sectoral Impact Model Intercomparison Project, January 11-15, 2021 (virtual).

Panelist, Workshop on The Security Implications of Global Climate Change, Center for Global Security Research, Lawrence Livermore National Laboratory, January 5-7, 2021 (virtual).

KAN-Risk Seminar, November 24, 2020 (virtual).

Stanford Graduate School of Business Executive Education, November 24, 2020 (virtual).

Keynote Lecture, Los Altos Public Library Science and Technology Week, October 7, 2020 (virtual).

Frontiers of Social Innovation: People, Power and Resources, May 14, 2020, Stanford, CA. (postponed due to COVID-19)

Science Lecture, Stanford Alumni Association, April 27, 2020, Washington, DC. (postponed due to COVID-19)

Science Lecture, Stanford Alumni Association, April 26, 2020, Cos Cob, CT. (postponed due to COVID-19)

Keynote Panel, UC Santa Cruz Climate Science and Policy Conference, May 1, 2020, Santa Cruz, CA. (postponed due to COVID-19)

Speaker, 2020 Stanford Family Weekend, February 29, 2020, Stanford, CA.

Keynote, Audubon Society Board of Directors, October 25, 2019, San Jose, CA.

Keynote, 2019 California Science Education Conference Climate Summit, October 17, 2019, San Jose, CA.

Knowledge Future 2019, Stanford University, August 25, 2019, Stanford, CA.

Workshop on Risk Analysis for Extremes in the Earth System, Lawrence Berkeley National Lab, July 22-24, 2019, Berkeley, CA.

Seminar, Jasper Ridge Biological Preserve, Stanford University, February 12, 2019, Portola Valley, CA.

Climate One at the Commonwealth Club of California, January 22, 2019, San Francisco, CA.

"The 2009 EPA Endangerment Finding: Even Stronger Evidence in 2018", Stanford Woods Institute Affiliate Event at the Global Climate Action Summit, September 14, 2018, San Francisco, CA

Science Lecture, Stanford Alumni Association, June 3, 2018, Rolling Hills, CA

Frontiers of Social Innovation: A Convening of Global Leaders, May 21, 2018, Stanford, CA

Stanford Woods Institute panel on Fire and the Future of California Forests, May 8, 2018, Sacramento, CA

Panelist, URx University Recruiting Conference, April 27, 2018, San Francisco, CA

Keynote Lecture, Founding Grant Society, Stanford University, April 19, 2018, Stanford, CA

Editors Panel, Stanford Libraries Gear Up For Research, April 17, 2018, Stanford, CA

Presentation to WWF National Council, April 17, 2018, Stanford, CA

Science Lecture, Ski and Snowboard Hall of Fame Induction Week, April 13, 2018, Olympic Valley, CA

International Discussion Series, Bechtel International Center, Stanford University, February 15, 2018, Stanford, CA

32nd Annual Timothy O'Leary Distinguished Scientist Public Lecture, Gonzaga University, February 12, 2018, Spokane, WA

2018 Acterra Lecture Series, February 8, 2018, Palo Alto, CA

Peer reviewer

Proposal Panelist: *DOE* (National Lab Climate Change Scientific Focus Areas; Regional Models for Climate Change Integrated Assessment; Climate and Earth System Modeling); *NASA* (Modeling, Analysis, and Prediction); *NOAA* (Climate Prediction Program for the Americas); NSF (CDI-II); *U.S. CLIVAR* (Drought in Coupled Models Project)

Proposal Referee: *AAAS* (EPSCoR; Canon National Parks Science Scholars Program); *Department of Energy* (NICCRC; Regional and Global Climate Modeling); *Government of Chile* (FONDECYT); *National Science Foundation* (Climate and Large-Scale Dynamics, Earth System History, Ecosystem Studies Program, Geography and Regional Science, Instrumentation and Facilities, Office of Polar Programs, Marine Geology and Geophysics, Paleoclimate, Paleo Perspectives on Climate Change, Partnerships for International Research and Education, Sedimentary Geology and Paleobiology)

Journal Manuscript Referee: *Agricultural and Forest Meteorology, Atmospheric Research, Bulletin of the American Meteorological Society, Climate Dynamics*, *Climate Research*, *Climatic Change*, *Earth Interactions, Eos, Geology, Geophysical Research Letters, Global and Planetary Change*, *International Journal of Climatology*, *International Journal of Environmental Research and Public Health*, *Journal of Applied Meteorology and Climatology, Journal of Climate*, *Journal of Geophysical Research – Atmospheres*, *Journal of Hydrometeorology*, *Limnology and Oceanography, Meteorological Applications*, *Nature*, *Nature Climate Change*, *Paleoceanography, Proceedings of the National Academy*

of Sciences, Quaternary International, Quaternary Research, Quaternary Science Reviews, Theoretical and Applied Climatology, Water Resources Management.

Book Referee: *Economics in the Climate Casino*; *Climate Impact Hotspots: Key Vulnerable Regions and Climate Change*

Report Referee: *California Energy Commission*, *State of Washington*

Workshops and conference sessions

Organizing Committee, Columbia University Workshop on Correlated Extremes, New York, NY, May 29-31, 2019.

Scientific Steering Committee, Aspen Global Change Institute workshop, "Impact Relevance and Usability of High Resolution Climate Modeling and Datasets," Aspen, CO, August 2-7, 2015.

Organizing Committee, Los Alamos Institute for Advanced Studies Workshop on Simulating the Spatial-Temporal Patterns of Anthropogenic Climate Change, Santa Fe, NM, August 3-5, 2011.

Organizing Committee, Climate Change Impacts and Integrated Assessment Workshop XVI, Snowmass, CO, July 27-August 4, 2011.

Organizing Committee, Climate Change Modeling and Scaling Workshop for the U.S. National Climate Assessment, Washington, D.C., December 8-10, 2010.

Co-Director, Fifth ICTP Workshop on the Theory and Use of Regional Climate Models, Trieste, Italy, May 31-June 11, 2010.

Co-Chair, *Paleoceanography and Paleoclimatology General Contributions*, 2009 American Geophysical Union Joint Assembly, Toronto, Canada, May 24-29, 2009.

Co-Chair, *Transitioning Out of the Mid-Holocene Climate: An Evaluation of Land-Ocean Proxy Records and Model Simulations*, AGU Fall Meeting, San Francisco, CA, December 15-19, 2008.

Co-Chair, *Regional-Scale Forcing of Climate*, AGU Fall Meeting, San Francisco, CA, December 15-19, 2008.

Co-Chair, *Climate of the Last Glacial-Interglacial Cycle: New Insights From Models and Data*, AGU Fall Meeting, San Francisco, CA, December 8-12, 2003.

4. POST-DEGREE HONORS AND AWARDS

Selected Honors

Fellow, American Geophysical Union	2020
William Kaula Award, American Geophysical Union	2020
Highly Cited Research, Clarivate Web of Science	2020
Timothy J. O'Leary, S. J., Distinguished Scientist, Gonzaga University	2018
Faculty Scholar, Stanford University	2015 – 2016
Stanford Fellow, Stanford University	2013 – 2015
Google Science Communication Fellow	2011
Kavli Fellow, U.S. National Academy of Sciences	2010, 2016
NSF CAREER Award	2010 – 2015
Terman Fellowship, Stanford University	2009 – 2012
University Faculty Scholar, Purdue University	2009
James R. Holton Award, American Geophysical Union	2006

Funded proposals

A Multi-Model, Multi-Scale Research Program in Stressors, Responses, and Coupled Systems Dynamics at the Energy-Water-Land Nexus, Department of Energy, August 1, 2016 to July 31, 2021, $941,845. (co-PI)

Extreme Event Analysis Tool in Support of UN Paris Agreement, Stanford Woods Institute for the Environment, October 1, 2016 to September 30, 2018, $199,950. (PI)

Secure Analytics on the Internet of Things, Stanford Data Science Initiative, February 1, 2015 to January 31, 2016, $184,000. (co-PI)

Assessing Climate Change Impact on Transportation Infrastructure Vulnerability and Sustainability, Stanford Woods Institute for the Environment, October 1, 2013 through September 30, 2015, $175,00. (co-PI)

Social vulnerability and climatic drivers of enteric disease in rural Ecuador, National Institutes of Health, September 1, 2011 to August 31, 2012, $21,548. (co-PI)

Large-scale solar energy conversion: Land and water impacts, Precourt Institute for Energy/TomKat Center for Sustainable Energy, Stanford University, September 1, 2011 to August 31, 2013, $285,533. (co-PI)

Holocene Climate Change in Southwestern Patagonia: New Insights from Large Lake Paleolimnology, National Science Foundation, February 1, 2011 to January 31, 2014, $592,251. (co-PI)

Research in Integrated Assessment Inter-Model Development, Testing and Diagnostics, Department of Energy, September 1, 2010 to July 31, 2016, $448,368. (co-PI)

CAREER: Dynamics and Impacts of Fine-Scale Climate Change, National Science Foundation, Award #0955283, August 1, 2010 to July 31, 2015, $443,795. (PI)

The Impact of Climate and Climate Change on West Nile Virus Transmission, National Institutes of Health, 1R01AI090159-01, July 15, 2010 to June 30, 2014, $676,048. (Subcontract)

The Science and Policy of Global Climate Change: Professional Development of K-12 Teachers, National Aeronautics and Space Administration, Grant #NNX09AL89G, September 1, 2009 to August 31, 2012, $569,967. (Co-I)

Impacts of Climate Change on Wildlife in the Southwest, United States Geological Survey, Award #G10AC00244, September 15, 2009 through September 14, 2012, $24,144. (Subcontract)

Impacts of High Resolution Extreme Events on U.S. Energy Demand and CO_2 Emissions in the 21st Century, Department of Energy, Award #DE-SC0001483, September 1, 2009 to August 31, 2011, $113,406. (PI)

The Response of Convective Precipitating Storms to Anthropogenically Enhanced Global Radiative Forcing, National Science Foundation, Award #0756624, September 1, 2008 to August 31, 2011, $616,110. (co-PI)

Impacts of High Resolution Extreme Events on U.S. Energy Demand and CO_2 Emissions in the 21st Century, Department of Energy, August 15, 2008 to August 14, 2009, $105,779. (PI)

Climate Variability and the Poor in Southern and Eastern Africa, The World Bank TFESSD, July 1, 2008 to November 30, 2010, $500,000. (Co-PI)

Collaborative Research: Water Balance of Western North America: Dynamics of the Miocene Summer Monsoon, National Science Foundation, Award #0450221, February 15, 2005 to January 31, 2009, $230,060. (PI)

Sub-Daily Scale Extreme Precipitation in Future Climate-Change Scenarios: A Pilot Study, National Science Foundation, Award #0402054, February 1, 2006 to January 31, 2009, $275,075. (Co-PI)

Collaborative Research: Investigation of Holocene Seasonality and Inter-Annual Variability Along the California Current System, National Science Foundation, Award #0402054, May 1, 2004 to April 30, 2008, $148,897. (PI)

Collaborative Research: Surface-Atmosphere Feedbacks and Holocene Climate Variations in Eastern North America: Linkages, Impacts, and Governing Mechanisms, National Science Foundation, Award #0315677. Subcontract with University of California, Santa Cruz, July 1, 2004 to September 30, 2007, $179,750. (Subcontract)

5. COMPLETE LIST OF SCHOLARLY PUBLICATIONS AND OTHER CREATIVE WORKS

Peer-reviewed publications

(underline denotes advisee; * denotes student thesis committee**)**
Total papers in print/press = 122
Google Scholar: https://scholar.google.com/citations?user=L1-cVvoAAAAJ&hl=en
ResearcherID: https://publons.com/researcher/2508066/noah-s-diffenbaugh/

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