Columbia Law School | COLUMBIA CLIMATE SCHOOL
SABIN CENTER FOR CLIMATE CHANGE LAW

February 1, 2023

Mathew C. Blum
Acting Administrator for Federal Procurement Policy
Office of Federal Procurement Policy
Office of Management and Budget
Washington, D.C. 20503

Re: Federal Acquisition Regulation: Disclosure of Greenhouse Gas Emissions and Climate-Related Financial Risk; FAR Case 2021-015, Docket No. FAR-2021-0015, Sequence No. 1

Dear Chairman Blum and Members of the Federal Acquisition Regulatory Council,

Columbia Law School's Sabin Center for Climate Change Law ("Sabin Center") and the undersigned climate scientists and other experts studying the effects of climate change respectfully submit these comments to the Department of Defense, General Services Administration, and National Aeronautics and Space Administration—collectively, the Federal Acquisition Regulatory Council (the "FAR Council")[1] —in response to their request for comments on the proposed rule titled "Disclosure of Greenhouse Gas Emissions and Climate-Related Financial Risk."[2]

The Sabin Center and the undersigned climate scientists and experts offer the comments below to explain how scientists know that human activities are driving global warming, and to highlight climate tools and data that companies use to evaluate climate-related risks to their businesses.

There is overwhelming scientific consensus on the fundamental reality of climate change: human activities are increasing atmospheric greenhouse gas ("GHG") concentrations, which is causing global average temperatures to rise. In a 2021 report, the Intergovernmental Panel on Climate Change ("IPCC") concluded that "[i]t is unequivocal that human influence has warmed

---

1 The Federal Acquisition Regulatory Council ("FAR Council") is comprised of the Administrator for Federal Procurement Policy, the Secretary of Defense, the Administrator of National Aeronautics and Space, and the Administrator of General Services, or their designees. *See* 41 U.S.C. § 1302(b).

2 Federal Acquisition Regulation: Disclosure of Greenhouse Gas Emissions and Climate-Related Financial Risk, 87 Fed. Reg. 68312 (November 14, 2022) [hereinafter the "Proposed Rule"].

the atmosphere, ocean and land."[3] The IPCC found that "[e]ach of the last four decades has been successively warmer than any decade that preceded it since 1850."[4] The extent of future temperature increases will depend, in large part, on future GHG emissions. However, "warming above 2 degrees Celsius is "very likely" unless emissions decline rapidly prior to 2050.[5] Rising temperatures are already increasing the frequency and severity of many types of weather extremes, such as heatwaves and floods, and contributing to sea-level rise and other slow-onset phenomena.[6]

Numerous studies confirm that climate change poses significant financial risks to corporate entities and the financial system more generally.[7] For example, a 2019 study by the CDP found that 215 of the largest companies globally face almost $1 trillion in potential financial risk from climate change, with approximately half of that risk identified as likely or nearly certain to materialize within five years.[8] More recently, in its 2021 report on Climate-Related Financial Risk, the Financial Stability Oversight Council ("FSOC") noted that "[t]he intensity and frequency of extreme weather and climate-related disaster events are increasing and already imposing substantial economic costs."[9] The FSOC recognized that, as the magnitude of climate hazards and associated costs increases in coming years, so too will risks to the financial system.[10] Thus, according to the FSOC, "climate-related financial risks are an emerging threat to the financial stability of the United States."[11] The Climate-Related Market Risk Subcommittee of the Commodity Futures Trading Commission ("CFTC") has similarly concluded that climate-related risks "are already impacting, or are anticipated to impact, nearly every facet of the U.S. economy."[12]

The financial risks associated with climate change are typically divided into two broad categories: (1) physical risks arising from the impacts of climate change on companies' assets, operations, and supply chains; and (2) transition risks arising from government and market

---

3 Intergovernmental Panel on Climate Change ("IPCC"), *Summary for Policymakers, in* CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS. CONTRIBUTION OF WORKING GROUP I TO THE SIXTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 4 (V. Masson-Delmotte et al., eds, 2021).

4 *Id*. at 5.

5 *Id*. at 13-15.

6 *Id*. at 15.

7 *See* FINANCIAL STABILITY OVERSIGHT COUNCIL, REPORT ON CLIMATE-RELATED FINANCIAL RISK (2021), https://perma.cc/6V34-EU4F; COMMODITY FUTURES TRADING COMMISSION CLIMATE-RELATED MARKET RISK SUBCOMMITTEE OF THE MARKET RISK ADVISORY COMMITTEE, MANAGING CLIMATE RISK IN THE U.S. FINANCIAL SYSTEM (2020), https://perma.cc/6RHX-XTW7; BOARD OF GOVERNORS OF THE FEDERAL RESERVE SYSTEM, FINANCIAL STABILITY REPORT (2020), https://perma.cc/2VWA-67LV.

8 CDP, MAJOR RISK OR ROSY OPPORTUNITY: ARE COMPANIES READY FOR CLIMATE CHANGE? (2019), https://perma.cc/XVL3-YF7T.

9 FINANCIAL STABILITY OVERSIGHT COUNCIL, *supra* note 7, at 10.

10 *Id*.

11 *Id*.

12 COMMODITY FUTURES TRADING COMMISSION CLIMATE-RELATED MARKET RISK SUBCOMMITTEE OF THE MARKET RISK ADVISORY COMMITTEE, *supra* note 7, at 11 & 28.

responses to climate change. These comments discuss the science of climate change detection and attribution—the body of research that helps to characterize the role of human activity in climate change—as well as how models are used to develop climate change projections. The goal of these comments is to explain how scientists know that anthropogenic GHG emissions are driving global warming which is, in turn, leading to other climate hazards (e.g., more severe heatwaves, droughts, and floods) that create risks for companies. The comments also highlight climate tools and data that companies can, and already do, use to evaluate climate-related risks to their assets, operations, work force, and supply chains. The sections below further explain these key points:

- There is a robust and growing body of evidence that establishes a causal connection between rising atmospheric GHG concentrations and physical climate hazards and associated impacts (e.g., water shortages, crop losses, and lost labor hours due to extreme heat).
- Climate models can be used to project future climate change hazards. Modeling climate change under different plausible GHG emissions scenarios provides a better method of estimating climate change impacts than incorrectly assuming that the climate of the recent past will simply continue unchanged into the future.
- Downscaled climate models can be used to refine projections from global climate models to finer scales (e.g., reflecting local climate hazards). Downscaled projections are available to companies and can be used by companies to identify climate hazards that may affect their assets, operations, work force, and supply chains. For example, using downscaled temperature projections, a company could identify potential risks to temperature-sensitive assets, such as natural gas generating plants. By comparing temperature projections to a generating plant's design reference temperature, a company could evaluate the potential for plant de-rates or outages in the future. Temperature projections could similarly be used with crop models to evaluate the potential for future crop losses. Sea level rise projections could also be overlaid on companies' asset maps to identify facilities at risk of nuisance flooding or permanent inundation.
- Some companies are already using downscaled climate projections to evaluate and disclose physical climate-related risks to their assets, operations, work force, and supply chains. Several examples are provided in Part 4 of this letter.

1. Climate Change Detection and Attribution

Attribution science refers to the body of research that explores the link between human activities and climate change.[13] According to the IPCC, distinguishing between the effects of

---

[13] Delliang Chen et al., *Framing, Context, and Methods, in* CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS. CONTRIBUTION OF WORKING GROUP I TO THE SIXTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL OF CLIMATE CHANGE 204 (V. Masson-Delmotte et al., 2021).

external influences and internal climate variability requires the direct comparison of observed changes in the climate system and those that are expected to result from external forcings, such as anthropogenic GHG emissions.[14] Formal detection and attribution studies use objective statistical tests to determine whether observations contain evidence of the expected responses to external forcing that is distinct from variability generated within the climate system itself.[15]

Attribution research can be broken down into four broad categories:

1. *Climate change attribution* examines how rising concentrations of GHGs and other pollutants in the atmosphere affect many other aspects of the global climate system, including global and regional mean temperatures, sea level, and sea ice extent.[16] Attribution studies have identified human-caused "fingerprint" patterns in literally dozens of different independently monitored variables. In fact, since the mid-1990s, these "pattern-based 'fingerprint' studies have been the primary and most rigorous tool for disentangling the complex causes of recent climate change."[17] Fingerprinting relies on numerical models of the climate system to provide estimates of both the searched-for fingerprint—i.e., the climatic response to a change in one or several forcing mechanisms—and the background "noise" of natural internal climate variability.[18] The internal and physical consistency of fingerprint results provides compelling scientific evidence of human effects on climate.

2. *Extreme event attribution* examines how human-induced changes in the global climate system have affected the probability, severity, and other characteristics of observed extreme events, such as hurricanes and heat waves. For example, one recent study used the Community

---

See also, Michael Burger, Jessica Wentz, and Radley Horton, *The Law and Science of Climate Change Attribution*, 45 COLUM. J. ENVTL. L. 57, 64 (2020).

14 G.C. Hegerl, et al., *Understanding and Attributing Climate Change*, *in* CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS. CONTRIBUTION OF WORKING GROUP I TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (S. Solomon et al., eds., 2007). *See also,* NAT'L ACAD. OF SCI., ENGINEERING, AND MEDICINE, ATTRIBUTION OF EXTREME WEATHER EVENTS IN THE CONTEXT OF CLIMATE CHANGE (2016).

15 Hegerl, et al., *supra* note14, at 667. Detection is the process of demonstrating that the climate has changed in some defined statistical sense, while 'attribution' refers to the process of establishing whether and to what extent human activities are the cause of the detected change. *See id*. at 667-668.

16 *See, e.g.,* Yang Chen, et al., *Future Increases in Arctic Lightning and Fire Risk for Permafrost Carbon*, 11 NAT. CLIMATE CHANGE 404 (2021); Lauren J. Vargo et al., *Anthropogenic Warming Forces Extreme Annual Glacier Mass Loss*, 10 NAT. CLIMATE CHANGE 856 (2020); Qiaohon Sun et al., *A Global, Continental, and Regional Analysis of Changes in Extreme Precipitation*, 34 J. CLIMATE 243 (2020).

17 Benjamn D. Santer, et al., *Human and natural influences on the changing thermal structure of the atmosphere*, 110 PROC. NAT'L ACAD. SCI. 17235 (2013).

18 *Id.* at 1.

Atmospheric Model ("CAM")[19] to analyze how human-induced climate change affected rainfall rates during the 2020 hurricane season, which is estimated to have resulted in more than $40 billion in damages.[20]

3. *Impact attribution* examines how changes in the global climate system affect human and natural systems. Impact attribution studies analyze localized physical climate change impacts, such as floods, droughts, and sea level rise, and the corresponding effects on infrastructure, public health, ecosystems, agriculture, and economies.[21]

4. *Source attribution* is a distinct but related body of research that aims to identify the relative contributions of different sectors, activities, and entities to global climate change.[22]

Climate change attribution, extreme event attribution, and source attribution are mature fields of research, with studies having been performed since the 1990s. Impact attribution is a newer, but rapidly developing, field of research. All four fields of research provide useful insights into how human activities affect the climate system which, in turn, informs modeling of future climate change.

2. Climate Modeling

This section describes the process of using climate models to generate knowledge of climate hazards. Modeling allows researchers to simulate and understand interactions between climate variables using physically-based representations of the climate system in numerical form. Through models, scientists can explore the effect of changes to external factors, like atmospheric GHG concentrations, on specific climate variables (e.g., surface temperatures) and the types of hazards associated with such GHG-induced effects (e.g., changes in rainfall patterns). Developing an understanding of the type of climate hazards present (e.g., in a given region, affecting a specific company, etc.) is a critical first step in assessing potential impacts of climate change. Using climate hazard data, companies can evaluate potential climate-related risks to their assets, operations, work force, and supply chains.

---

19 All raw CAM model output is publicly available on the National Center for Atmospheric Research Globally Accessible Data Environment. *See* Nat'l Ctr. Atmospheric Research, *Data Services: Access, Tools & Guidance*, https://perma.cc/Y3ZX-ZX7G (last visited Dec. 5, 2022).

20 *See* Kevin A. Reed et al., *Attribution of 2020 Hurricane Season Extreme Rainfall to Human-Induced Climate Change*, 13 NATURE COMM. 1905 (2022).

21 As an example, one recent impact attribution study examined how increases in the number of wet days and in extreme daily rainfall affect economic growth rates. *See* Maximillian Kotz et al, *The effect of rainfall changes on economic production*, 601 NATURE 223 (2022).

22 Source attribution studies have, for example, assessed the cumulative GHG emissions attributable to specific oil, natural gas, coal, and cement producers (among others). *See, e.g.,* RICHARD HEEDE, CARBON MAJORS: ACCOUNTING FOR CARBON AND METHANE EMISSIONS 1854–2010: METHODS & RESEARCH REPORT (2014), https://perma.cc/448G-SYUA.

Research shows that past model predictions (e.g., of global average temperatures) have been highly accurate. One way to assess model accuracy is to compare previous model projections made years or decades ago to actual climate observations—a process referred to as "hindcasting." One recent study used hindcasting to assess the performance of climate model projections published between 1970 and 2007.[23] The authors found that the climate models were "skillful in predicting subsequent GMST [global mean surface temperature] changes, with most models examined showing warming consistent with observations" and that there was "no evidence that the climate models […] systematically overestimated or underestimated warming over their projection period."[24] Another study analyzed global temperature and sea-level data over the past several decades and compared those records with projections published in the IPCC's Third and Fourth Assessment Reports. The analysis showed that "global temperature continues to increase in good agreement with the best estimates of the IPCC, especially if we account for the effects of short-term variability due to the El Niño/Southern Oscillation, volcanic activity, and solar variability."[25]

2.1. Types of Climate Models

Each component of the climate system—or a combination of components—can be represented by models of varying degrees of complexity.[26] There are three classes of climate models:

1. Energy balance models, which are the oldest and simplest type of climate model, estimate changes in the climate system from an analysis of the Earth's energy budget (i.e., the balance of energy entering and leaving the Earth).[27]

2. Intermediate complexity models, which are similar to energy balance models but incorporate the effect of changes in the Earth's land, oceans, and ice features on the climate.[28] Intermediate complexity models are used to project changes in climate over long time scales and large spatial scales.[29]

3. Comprehensive climate models (General Circulation Models and full Earth System Models), which are more sophisticated than energy balance and intermediate complexity models.[30]

---

23 Zeke Hausfather, et al., *Evaluating the Performance of Past Climate Model Projections*, 47 GEOPHYSICAL RES. LETTERS 1 (2020).

24 *Id*. at 1, 7-8.

25 Stefan Rahmstorf, et al., *Comparing climate projections to observations up to 2011*, 7 ENVTL. RES. LETTERS 4 (2012).

26 *Id*.

27 Lauren Harper, *What are climate models and how accurate are they?* STATE OF THE PLANET BLOG (May 18, 2018), https://perma.cc/3QJ6-Q2UR.

28 *Id*.

29 *Id*.

30 *Id*.

General Circulation Models are based on physical laws that describe the fully-coupled dynamics of the atmosphere and ocean, expressed through mathematical equations.[31] Earth System Models, also referred to as coupled carbon-cycle climate models, are similar to General Circulation Models but also incorporate the dynamics of the land surface, vegetation, the carbon cycle, and other elements of the climate system.[32] Both General Circulation Models and Earth System Models are built upon the fundamental laws of physics or the empirical relationships established from observations and, when possible, are constrained by fundamental conservation laws.[33]

There are more than forty scientific institutions worldwide that develop climate models.[34] In order to facilitate comparison of model results across these institutions, the Coupled Model Intercomparison Project ("CMIP") serves as a framework for climate model experiments, allowing scientists to compare and assess climate models in a systematic way.[35] The most recent, sixth phase of CMIP model runs ("CMIP6") provided many different types of simulations that were evaluated by the IPCC's Sixth Assessment Report. As part of CMIP6, there are twenty-two specialized experiments—called Model Intercomparison Projects ("MIPs")—which prescribe standardized experiment designs, time periods, output variables or observational reference dates to better facilitate the direct comparison of climate models.[36]

2.2. Climate Model Projections

The first step in simulating and quantifying the climate response to past, present, and future human activities is to simulate historical and/or present climate for extended simulation periods, typically across multiple decades or several centuries. Models can be used to simulate a previous climate before anthropogenic GHG emissions became prominent, as well as to simulate the effect of natural factors (e.g., volcanic activity and changes in the Sun's energy activity) and human activities on the climate.[37] Two general types of simulation are typically performed to make projections of future changes in the climate system:

1. Equilibrium simulations involve changing the CO_2 concentrations (e.g., doubling the CO_2 level) and running the model again until it reaches a new equilibrium. Modelers can then

---

[31] Chen, et al., *supra* note 16, at 215.
[32] *Id*.
[33] *Id*.
[34] Zeke Hausfather, *CMIP6: The next generation of climate models explained*, CARBON BRIEF (Dec. 2, 2019, 8:00 AM), https://perma.cc/F69B-R3U6.
[35] Zeke Hausfather, *Q&A: How do climate models work?* CARBON BRIEF, https://perma.cc/8LVD-HZ4Y (Jan. 15, 2018, 8:30 AM).
[36] Chen, et al., *supra* note 16, at 182.
[37] E. Ahlonsou et al., *The Climate System: An Overview, in* CLIMATE CHANGE 2001: THE SCIENTIFIC BASIS, CONTRIBUTION OF WORKING GROUP I TO THE THIRD ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 95 (J.T. Houghton et al., eds., 2001).

estimate the corresponding changes to the climate based on the doubling of CO_2 emissions by calculating the differences between the climate statistics in the "doubled CO_2" and "pre-industrial CO_2" simulations.[38]

2. Transient simulations involve forcing the model with a specific scenario of future changes in GHG emissions, particulate pollution, and land surface properties. For example, the IPCC has developed a set of scenarios that represent different time-dependent "storylines" of GHG and aerosol concentrations based on differing assumptions regarding population growth, energy intensity and efficiency, and economic growth.[39] (Climate modeling using emissions scenarios is discussed further in Part 2.3 below.)

2.3. Climate Modeling Using Emission Scenarios

Representative Concentration Pathways ("RCPs") were used in simulations of future climate change that were assessed in the IPCC's Fifth Assessment Report. RCPs provide four different scenarios for GHG emissions in the 21st Century, as well as for air pollutant emissions and changes in land use. Each RCP is defined by its emissions pathway and total radiative forcing[40] by 2100.[41] Broadly speaking, the RCP scenarios consist of a stringent GHG emissions mitigation scenario (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0), and one high emissions scenario (RCP8.5).

The RCP scenarios were assessed by the IPCC using Integrated Assessment Models ("IAMs"). IAMs typically incorporate simple climate models (such as the Energy-Balance Models described above), carbon cycle models, and social science models that consider demographic, political, and economic variables that influence GHG emission scenarios.[42] Each RCP was generated using IAMs to estimate the changes in radiative forcing through 2100 associated with each of the four "storylines."

RCP data are publicly available for download and use to make 21st century climate change projections under different emission scenarios.[43] Many different entities, including management consulting firms such as McKinsey & Company, already use climate models driven by RCPs to

---

38 *Id.*

39 *Id.*

40 Radiative forcing is a cumulative measure of human-caused perturbations to Earth's energy balance, expressed in Watts per square meter.

41 IPCC, *Representative Concentration Pathways (RCPs)*, DATA DISTRIBUTION CENTRE, https://perma.cc/3475-P4JY.

42 IAMs differ from General Circulation Models, which focus solely on modeling the physical climate system. *See* CENTER FOR INTERNATIONAL EARTH SCIENCE INFORMATION NETWORK, THEMATIC GUIDE TO INTEGRATED ASSESSMENT MODELING OF CLIMATE CHANGE (1995), https://perma.cc/R57L-7KGP.

43 *See* RCP Database, Version 2.0.5, https://tntcat.iiasa.ac.at/RcpDb/dsd?Action=htmlpage&page=download.

assess the physical risks of climate change. For example, in a recent report by the McKinsey Global Institute ("McKinsey Report"), the authors used RCP8.5 in their analysis of future physical climate risks. They found that by 2050:

- global average temperatures are expected to warm by 2.3 degrees Celsius relative to the preindustrial baseline;
- the time spent in drought is projected to increase such that, in some areas (e.g., parts of the Mediterranean, Africa, and the Americas), drought conditions could occur up to eighty percent of each decade; and
- the likelihood of extreme precipitation events is expected to increase more than fourfold along the east coast of North America (compared to the period from 1950-1981).[44]

This information can then be used to estimate the socioeconomic impacts of climate change associated with different emissions trajectories. For example, the McKinsey Report identified "the socioeconomic risk from acute hazards, which are on-off events like floods or hurricanes, as well as from chronic hazards, which are long-term shifts in climate parameters like temperature" from 2020 to 2030 and from 2030 to 2050.[45] Among other things, the report found that temperature increases associated with RCP8.5 will mean that:

> "By 2030 […] between 250 million and 360 million people could live in regions where there is a non-zero probability of a heat wave exceeding the threshold for survivability for a healthy human being in the shade (a measure of livability, without factoring in air conditioner penetration). The average probability of a person living in an at-risk region experiencing such a lethal heat wave at least once over the decade centered on 2030 is estimated to be approximately 60 percent[.] By 2050, the number of people living in regions exposed to such heat waves could rise further, to between 700 million and 1.2 billion [...] The global average number of working hours that could be lost due to increasing heat and humidity in exposed regions (a measure of workability impacts) could almost double by 2050, from 10 percent to 15 to 20 percent."[46]

The IPCC's Sixth Assessment Report highlights a newer set of illustrative scenarios, derived from five Shared Socio-economic Pathways ("SSPs"), which encompass a range of possible future developments with respect to anthropogenic drivers of climate change.[47] Each pathway is built upon an internally consistent, plausible, and integrated description of a socio-economic future.[48] They include quantitative projections of socio-economic drivers, including

---

44 JONATHAN WOETZEL, ET AL., MCKINSEY GLOBAL INSTITUTE, CLIMATE RISK AND RESPONSE: PHYSICAL HAZARDS AND SOCIOECONOMIC IMPACTS 10 (2020), https://perma.cc/55NE-TVTU.

45 *Id*. at 2.

46 *Id*. at 23 (Internal citations omitted).

47 Chen, et al, *supra* note 16, at 230.

48 *Id*.

population, gross domestic product, and urbanization. The five SSPs represent: "sustainability" (SSP1), a "middle-of-the-road" path (SSP2), "regional rivalry" (SSP3), "inequality" (SSP4), and "fossil fuel-intensive" development (SSP5). The narratives and drivers underlying each SSP were used to develop scenarios of energy use, air pollution control, land use, and GHG emissions using IAMs.[49]

Like RCPs, SSPs yield information about the approximate radiative forcing level in 2100. This information is encoded in the name of the SSP (SSPX-Y, where 'X' represents the Shared Socio-economic Pathway family (1-5), and 'Y' represents the approximate radiative forcing level in 2100). These combinations are widely used in the climate impact studies assessed in the IPCC Sixth Assessment Report.[50] For example, the IPCC describes SSP5-8.5 as a "high reference scenario with no additional climate policy. CO_2 emissions roughly double from current levels by 2050" in SPP5-8.5.[51] According to the IPCC, the SSP and RCP scenarios "are designed to span a plausible range of future pathways," and can be used to develop projections of future climate conditions in various possible futures.[52]

2.3. Downscaling Climate Models

General circulation models generally divide the world up into grids in order to perform calculations. A typical model might have a grid cell size of sixty miles or more for one side of the cell, resulting in coarse-resolution projections that cover large geographic areas. These projections may not be sufficiently granular to enable companies to fully assess the impacts of climate change on specific assets and operations. Downscaling the output from global climate models to finer spatial scales can partially bridge this information gap. There are two main approaches to downscaling:

1. Dynamical downscaling uses higher spatial resolution regional climate models to directly simulate regional climate processes and regional responses to global change.[53] The regional models usually cover a selected domain (such as the continental United States) and receive information from more coarsely resolved general circulation models at the boundaries of the regional domain.

2. Statistical downscaling uses historically-based statistical relationships between the large-scale and local-scale climate to estimate future changes in local climate from large-scale general circulation model projections.[54]

---

49 *Id.*

50 *Id.* at 231.

51 *Id.*

52 *Id*. at 196.

53 Aristita Busuioc, *Empirical-statistical downscaling: Nonlinear statistical downscaling*, OXFORD RESEARCH ENCYCLOPEDIA OF CLIMATE SCIENCE (2021).

54 *Id*. at 1.

Downscaling climate models can reveal useful information about a company's exposure to acute and slow-onset climate changes. Information regarding where climate hazards are likely to be felt may allow a company to assess which of its physical assets, operations, and supply chains are located in areas known to be vulnerable to climate hazards. Such an assessment may enable the company to better understand the nature and extent of any climate-related vulnerabilities. Companies can use climate models that produce a probabilistic assessment[55] of hazards within a given area to identify risks to assets in the affected region.[56] This would enable the company to disclose, for example, that its principal place of business is situated within a geographic area that scientists have concluded is *very likely* [90-100% outcome probability] to experience flooding exacerbated by climate change.

Downscaled climate projections have been published by various governmental and academic institutions:

- The Department of Energy, National Aeronautics and Space Administration, and National Oceanic and Atmospheric Administration have jointly published zip-code-level temperature projections and county-level precipitation and sea level projections.[57]
- The U.S. Geological Survey has partnered with the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University to develop a "Regional Climate Change Viewer" that includes downscaled projections for over 60 climate variables, including air temperature and precipitation.[58]
- The Bureau of Reclamation has partnered with multiple universities and non-governmental organizations to develop downscaled projections for temperature and precipitation at the watershed level. The projections are designed to enable assessment of climate change impacts on watershed hydrology, ecosystems, and water and energy demand across the U.S.[59]

---

55 Probabilistic assessments indicate areas where, for example, models show a higher chance of above or below average temperatures or precipitation. *See* NOAA, *Climate Models*, CLIMATE DATA PRIMER, https://perma.cc/HL6K-33Y4 (last visited Dec. 4, 2022).

56 *See, e.g.,* ISIMIP, *The Inter-Sectoral Impact Model Intercomparison Project*, https://perma.cc/UV5D-PBXQ (last visited Dec. 4, 2022). Utilizing climate model output at a more granular level than the model itself operates—i.e., downscaled data—requires an acknowledgment that the local risk of exposure to an extreme event may differ from what the model predicts at a larger scale.

57 *See Energy Data Gallery*, U.S. CLIMATE RESILIENCE TOOLKIT, https://toolkit.climate.gov/topics/energy/energy-data-gallery (last updated Sept. 24, 2019).

58 U.S. Geological Survey, *Regional Climate Change Viewer*, http://regclim.coas.oregonstate.edu/visualization/rccv/index.html (last visited Dec. 4, 2022).

59 U.S. Bureau of Reclamation et al., *Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections*, https://gdo-dcp.ucllnl.org/downscaled_cmip_projections/#Welcome (last visited Dec. 4, 2022).

- The Geospatial Innovation Facility at the University of California at Berkeley has developed Cal-Adapt, a web-based tool that provides projections for several climate variables, including temperature and precipitation, under two climate change scenarios on a 3.5 × 3.5-mile spatial grid.[60]
- The Climate Impact Lab has developed the Global Downscaled Projections for Climate Impacts Research, a globally downscaled version of temperature and precipitation from the most recent CMIP6 projections, with a resolution of approximately 15 miles.[61]
- The Department of the Interior and National Oceanic and Atmospheric Administration have developed a Climate Mapping for Resilience and Adaptation assessment tool, which integrates information from across the federal government to help people assess their local exposure to climate-related hazards.[62]

3. Overcoming Challenges and Uncertainties

Climate science is sufficiently robust to assess the likelihood of certain climate change hazards and evaluate their impacts on companies' assets and operations. There are, however, remaining uncertainties and limitations in how climate science can be used. As explained in this section, researchers have techniques and language to address these challenges, with the goal of ensuring that climate science remains a source of useful information about the climatic future. A particular focus of previous research has been to identify climate change responses that are robust across a wide range of different climate models, that are interpretable in terms of basic, well-understood physics (such as the decrease in snowpack associated with human-caused warming), and that have reliable multi-decadal observational records.

As noted above, scientists can assess how well a climate model functions by comparing its outputs to observational data. However, observational data may sometimes be incomplete, or entirely unavailable. Modeling climate impacts at fine geographic scales (e.g., regionally or locally) can result in additional sources of uncertainty due to downscaling or bias correction.[63] For example, statistical downscaling relies on the assumption that the statistical relationships used to transform global climate model output remains true under novel environmental conditions that

---

60 CAL-ADAPT, *About Cal-Adapt*, https://cal-adapt.org/about/ (last visited Dec. 4, 2022).

61 Climate Impact Lab, Introducing Our New Global Downscaled Projections for Climate Impact Research, https://impactlab.org/news-insights/introducing-our-new-global-downscaled-projections-for-climate-impacts-research/ (last visited Dec. 4, 2022).

62 Climate Mapping for Resilience and Adaptation, *About CMRA*, https://resilience.climate.gov/pages/about/#about (last visited Nov. 28, 2022).

63 Bias correction refers to the correction of projected raw, daily global circulation model output using the differences in the mean and variability between general circulation models and observations over a set reference period. *See* Ed Hawkins et al., *Calibration and bias correction of climate projections for crop modelling: An idealised case study over Europe. Agricultural and Forest Meteorology*, 170 AGRICULTURAL & FOREST METEOROLOGY 19 (2013).

have yet to be observed directly.[64] One strength of using dynamical downscaling methodologies is that such models rely on explicit representations of physical principles in the atmosphere that are expected to hold true under climate change, but this method can be sensitive to large-scale biases in the downscaling models (and in the global climate models used to generate the data being downscaled).[65]

Researchers can address these uncertainties by articulating the nature and extent to which local climate predictions may differ from regional predictions modeled at a larger scale. Assume, for example, that researchers want to study the future climate impacts on a particular city in North America. While regional modeling may suggest that North America will experience an increase in average surface temperatures, an individual city may experience more or less warming than the average for the continent. This variation can be investigated by analyzing regional-scale climate processes and factors such as land use, aerosol concentrations, and small-scale natural variability in the area of interest. Uncertainties in the observational data can also be studied and may influence attribution of observed climate changes and/or impacts to specific causal factors. For example, the IPCC states that the scarcity of temperature recording stations can explain the overall low confidence in changes in surface air temperatures in the Antarctic region.[66]

The results of individual studies are typically expressed in terms of calibrated uncertainty and likelihood language. For example, the IPCC's Sixth Assessment Report uses a framework for applying expert judgment in the evaluation and characterization of assessment findings. This calibrated language is designed to consistently evaluate and communicate uncertainties associated with incomplete knowledge due to a lack of available information, or from disagreement regarding what is known or even knowable.[67] This methodology assigns qualitative expressions of confidence—such as *very low, low, medium, high,* and *very high*—based on the robustness of evidence for a finding and uses quantitative expressions—such as *virtually certain* (99-100% probability)—to describe the likelihood of a finding.[68] For example, the IPCC report states that "observed increases in areas burned by wildfires have been attributed to human-induced climate change in some regions (*medium* to *high confidence*)."[69] Language of this kind is used to manage

---

64 Geophysics Fluid Dynamics Laboratory, *Climate Model Downscaling*, https://perma.cc/K25U-3UYS (last visited Nov. 28, 2022).

65 *Id*.

66 Nathaniel L. Bindoff, et al., *Detection and Attribution of Climate Change: from Global to Regional, in* CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS. CONTRIBUTION OF WORKING GROUP 1 TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (T.F. Stocker et al. eds., 2013).

67 Hans Pörtner, et al., *Technical Summary, in* CLIMATE CHANGE 2022: IMPACTS, ADAPTATION AND VULNERABILITY. WORKING GORUP II CONTRIBUTION TO THE IPCC SIXTH ASSESSMENT REPORT (Hans-Otto Pörtner et al. eds., 2022).

68 *Id.* at 4.

69 Hegerl, et al., *supra* note 14, at SPM-8.

uncertainties in a rigorous, systematic way.[70] Of course, the language scientists have developed to address unavoidable uncertainty in this enterprise must not be confused with the reliability of the results and conclusions.

In sum: as in any scientific endeavor, some uncertainties are unavoidable, but researchers can frame results at an appropriate scale and use language that clearly communicates the extent to which modeling and observations produce results with a high level of confidence. Such techniques allow companies to effectively use model outputs to assess climate-related risks to their assets and operations. The case studies included below further demonstrate this point.

4. Case Studies

The case studies below highlight how companies can and do make use of the data and analytical techniques highlighted in these comments to assess climate hazards, evaluate potential impacts on their assets, operations, and supply chains, and communicate useful information about their exposure to physical climate related risks.

4.1. Con Ed's Climate Vulnerability Study

Following Hurricane Sandy in 2012, the Consolidated Edison Company of New York ("Con Ed") conducted a comprehensive climate change vulnerability study to evaluate the likelihood and consequences of a range of climate change scenarios.[71] The study provides an example of how companies can conduct—and ultimately disclose—an assessment of physical climate-related risks and hazards.

Con Ed's vulnerability study evaluated climate change trends and potential extreme weather events across the company's service territory over three-time horizons: near (2030), intermediate (2050), and long-term (2080).[72] The study focused on climate variables that could impact Con Ed's operations, planning, and infrastructure, namely temperature, humidity, precipitation, sea level rise and coastal flooding, extreme events, and multiple or compounding events.[73]

For each climate variable mentioned above, the study team used a broad model ensemble—consisting of 32 global climate models—to address differences across models and to provide a more comprehensive view of future climate in the region.[74] Each global climate model was

---

70 *See* Elisabeth A. Lloyd et al., *Climate Scientists Set the Bar of Proof Too High*, 165 CLIMATIC CHANGE 55 (2021) ("[C]limate scientists have set themselves a higher level of proof in order to make a scientific claim than law courts ask for in civil litigation in the USA, the UK, and virtually all common law countries.").

71 CONSOLIDATED EDISON, CLIMATE CHANGE VULNERABILITY STUDY (2019), https://perma.cc/39E4-B77T. [Included as Attachment 1 to this letter]

72 *Id*. at 17.

73 *Id*.

74 *Id*.

simulated using RCP4.5 and RCP8.5 to evaluate climate change hazards and account for model uncertainty under each RCP scenario.[75] In order to achieve a more accurate representation of the local climate across the New York Metropolitan Region (i.e., Con Ed's service territory), the study team bias corrected and downscaled the global climate model projections using weather station data over a 1976-2005 historical baseline from three weather stations across the service territory.[76]

The Con Ed study revealed specific, actionable information about the impacts of climate change on the company's assets and operations. For example, the climate projections developed for the study showed a significant increase in the number of days with average temperatures above 86°F (up 1200 percent) and days with maximum temperatures above 95°F (up 575 percent) by 2050, which "create potential risks for Con Ed[] as they drive demand for air conditioning and stress electrical and infrastructure systems."[77] The study further showed that Con Ed's system could be impacted by sea level rise and associated coastal flooding. According to climate projections, by 2100, 500-year flood events are expected to occur every ten years and the water-depth of present-day 100-year floods is expected to increase by up to fifty percent.[78] The vulnerability study determined that, with this increase in flood height, at least seventy-five of Con Ed's electric substations would be vulnerable to flooding during a 100-year storm.[79] Con Ed would need to spend $636 million to harden those seventy-five substations.[80]

Where quantitative results were not available for specific climate-related risks, the study described those risks in qualitative terms. For example, the study notes that "the percentage of very strong and destructive (i.e., Categories 4 and 5) hurricanes is projected to increase in the North Atlantic basin. It can therefore be argued that climate change could make it more likely for some of these storms to impact the New York Metropolitan Region, although the most dominant factor will remain unpredictable climate and weather variability."[81]

Based on the findings of the vulnerability study, Con Ed was able to identify specific assets that face physical climate risks and develop a plan to manage those risks (e.g., by replacing or hardening assets). After completing the vulnerability study, Con Ed developed a Climate Change Implementation Plan that explains how it "will incorporate climate change projections for heat, precipitation, and sea level rise from the […] study into its operations to mitigate climate change risks to its assets and operations and establishes an ongoing process to reflect the latest science in the Company's planning."[82] The Implementation Plan identifies 5-, 10-, and 20-year actions that

---

75 *Id*.
76 *Id*.
77 *Id*. at 19-20.
78 *Id*. at 23-24.
79 *Id*. at 44.
80 *Id*.
81 *Id.* at 24-25.
82 CONSOLIDATED EDISON, CLIMATE CHANGE IMPLEMENTATION PLAN 1 (2020), https://perma.cc/A32Z-JPGS.

Con Edison will take with respect to load forecasting, load relief planning, reliability planning, asset management, system planning, emergency response activities, and worker safety protocols.[83] The actions include elevating new critical electrical infrastructure in floodplains by three-feet to account for sea level rise and reduce the risk of inundation during coastal storms.[84]

In summary, the Con Ed vulnerability study serves as a representative example of how companies can use the techniques highlighted in this letter to identify, evaluate, and ultimately disclose physical climate-related risks to their assets and operations.

4.2. UNEP FI's Climate Risk Landscape Assessment

A 2021 report from the United Nations Environment Programme Finance Initiative ("UNEP FI") illustrates the range of data and analytical techniques available to assess climate hazards; evaluate potential impacts on assets, operations, and supply chains; and communicate useful information about exposure to physical climate-related risks.

The report, titled *The Climate Risk Landscape* ("Landscape Report") surveyed various climate risk assessment tools used by financial institutions to evaluate and disclose physical and transition risks associated with climate change.[85] The Landscape Report reviews nineteen commercially-available tools for assessing physical climate risk and eighteen commercially available transition risk assessment tools.[86] With respect to the former, the Landscape Report finds that existing tools can be used to evaluate acute risks associated with extreme weather events, flooding, wildfires, and landslides, as well as chronic risks associated slow onset climate change impacts, such as sea level rise.[87] The Landscape Report further notes existing tools are "being constantly updated to allow for more granular analysis that takes into account a broader, more plausible set of scenarios," and enables financial institutions to "provide consistent and market-ready disclosures."[88] According to the Landscape Report, physical risk data is becoming easier to access in formats that are "easily usable by financial institutions."[89]

Following release of the 2021 Landscape Report, UNEP FI ran a pilot program in which forty-eight global banks and investors were given an opportunity to learn about, and trial, twelve

---

83 *Id.* at 2.
84 *Id.* at 8.
85 PAUL SMITH, UNEP FI, THE CLIMATE RISK LANDSCAPE: A COMPREHENSIVE OVERVIEW OF CLIMATE RISK ASSESSMENT METHODOLOGIES (2021), https://www.unepfi.org/publications/banking-publications/the-climate-risk-landscape/. [Included as Attachment 2 to this letter]
86 *Id.* at 15 & 29.
87 *Id.* at 32.
88 *Id.* at 35 & 37.
89 *Id.* at 37.

commercially available climate risk assessment tools.[90] The tools modeled impacts under several RCP scenarios.

The program participants included TD Asset Management Inc. ("TDAM"), which manages $434 billion in assets on behalf of 3 million investors.[91] TDAM trialed emissions analysis, climate scenario alignment analysis, transition risk analysis, and physical risk analysis tools made available by Institutional Shareholder Services ("ISS") ESG.[92] We focus here on the physical risk analysis tool, which TDAM used to "measure[ ] the potential financial impact of the six most costly natural climate hazards such as floods, droughts or wildfires on the value of" a global equity portfolio that held 195 securities from over thirty countries.[93] TDAM's analysis showed that physical climate risks are projected to result in a 1.6 percent and 2.8 percent change in portfolio value by 2050 under the most likely and worst-case RCP scenarios, respectively, and that "80% of the climate value-at-risk of the portfolio can be attributed to just 30 securities."[94] TDAM also used the ISS ESG tool to evaluate the financial risks posed by specific climate impacts and found that wildfires and heat stress presented the greatest risk to its portfolio.[95]

Another participant in the pilot program was Intesa Sanpaolo, an Italian bank that serves 13.5 million customers and has €341 billion in assets under management.[96] Intesa Sanpaolo worked with Risk Management Solutions, Inc. ("RMS"), which has developed over 300 catastrophe risk models that can be used to assess "how frequently a given location can be expected to be impacted" by a particular hazard (e.g., flooding in excess of six feet), as well as "the frequency and severity of the economic impact caused by" the hazard.[97] RMS used the models to quantify the flood risk of a sample of Intesa Sanpaolo's mortgage portfolio in regions throughout Italy under RCP6.0 and RCP8.5.[98] Using RMS data, Intesa Sanpaolo calculated the impact on Loss Given Default and the Probability of Default to range from five to thirty-nine percent of the initial values.[99] Intesa Sanpaolo further estimated, under RCP8.5, the average annual loss would increase fifty percent over the baseline in the provinces of Rome and Naples by 2040.[100]

---

90 DAVID CARLIN & ALEXANDER STOPP, UNEP FI, THE CLIMATE RISK TOOL LANDSCAPE: 2022 SUPPLEMENT (2022), https://www.unepfi.org/publications/the-climate-risk-tool-landscape-2022-supplement/. [Included as Attachment 3 to this letter]
91 TD Asset Management, *About Us*, https://perma.cc/8AR9-AXPN (last visited Dec. 6, 2022).
92 CARLIN & STOPP, *supra* note 91, at 38-39.
93 *Id*. at 39.
94 *Id*. at 42.
95 *Id*. at 43.
96 Intesa Sanpaolo, *Business*, *About Us*, https://perma.cc/QU5L-VXT2 (last Dec. 6, 2022).
97 CARLIN & STOPP, *supra* note 91, at 26 & 62.
98 *Id*. at 64.
99 *Id*. at 66.
100 *Id*. at 65.

A third pilot program participant was Desjardins Group, a financial cooperative with over seven million members and customers, and over $397 billion in assets.[101] Desjardins partnered with The Climate Service ("TCS"), which used its Climanomics platform to evaluate physical and transition risks across fifty of Dejardins' real assets.[102] The Climanomics platform models absolute climate risk, measured in millions of USD and relative climate risk, reported as percent of asset value.[103] The analysis of Dejardins' assets revealed that fluvial flooding is the greatest physical risk to the assets under both RCP4.5 and RCP8.5 scenarios.[104] Drought was identified as the second greatest physical risk to the assets.[105] Desjardins was able to conduct asset-level risk analyses. For example, the analysis showed that a dairy farm located northeast of Montreal, Canada, would "face a modeled average annual loss (MAAL) of 6.7% to 8.5% for RCP4.5 and RCP8.5, respectively."[106] The analysis further showed that "[t]he highest risks faced are from temperature extremes, followed to a lesser degree by fluvial flooding and drought at both RCP4.5 and RCP8.5 scenarios. The largest difference among the two is temperature extremes representing a 5.7% MAAL in RCP8.5 and 3.9% MAAL in RCP4.5."[107]

The above examples demonstrate how companies can use existing tools to evaluate, and ultimately disclose, the physical risks they face from flooding, drought, and other climate change impacts. As UNEP FI has noted, climate risk assessment methodologies are advancing rapidly, and new tools are becoming available.[108] UNEP FI predicts that physical risk models will continue to improve and provide increasingly "granular" data that will "allow [ ] more accurate risk analysis."[109]

4.3. Rio Grande Project EIS

The Bureau of Reclamation's Final Environmental Impact Statement ("EIS") for the Rio Grande Project provides another example of how private companies can use climate science to understand and communicate the physical risks of climate change.[110]

The Rio Grande Project supplies irrigation to about 178,000 acres of land and provides electrical power for communities and industries in the area. Physical features of the project include

---

101 Desjardins Group, *Quick facts about Desjardins*, https://perma.cc/7HHX-XPXQ (last visited Dec. 6, 2022).

102 CARLIN & STOPP, *supra* note 91, at 80.

103 *Id*.

104 *Id*. at 84.

105 *Id*.

106 *Id*. at 85.

107 *Id*. at 85.

108 *Id*. at 8; SMITH, *supra* note 86, at 35.

109 SMITH, *supra* note 86, at 37.

110 BUREAU OF RECLAMATION, FINAL ENVIRONMENTAL IMPACT STATEMENT: CONTINUED IMPLEMENTATION OF THE 2008 OPERATING AGREEMENT FOR THE RIO GRANDE PROJECT, NEW MEXICO AND TEXAS (2016), https://perma.cc/K3YN-8C5T. [Included as Attachment 4 to this letter]

the Elephant Butte and Caballo dams, as well as hundreds of miles of canals and associated infrastructure, and a hydroelectric plant. The project's climate impact analysis was designed to understand how the management of this system would operate under future climate conditions through 2050. Therefore, the EIS used climate model output generated from an ensemble of 112 statistically downscaled projections and developed three possible scenarios—a drier scenario, a median or "central tendency" scenario, and a wetter scenario. Hydrology models were then used to simulate changes in runoff and streamflow across the river basin of the Rio Grande using these three precipitation scenarios.

In the EIS, the study authors were able to isolate "worst case" scenarios for various regions across the river basin. For example, the wetter scenario represented a worst case for species that inhabit the Elephant Butte reservoir, while the drier scenario is the worst case for species located downstream of the Caballo dam. This study further demonstrates the techniques outlined in this letter, such as employing qualitative narratives as appropriate and using ensemble data from multiple climate models, can produce critical information that characterizes the climate risk to a company's physical assets.

5. Conclusion

As the IPCC has recognized, it is "unequivocal" that human activities are warming the planet, leading to "widespread and rapid changes" that pose significant economic and other risks.[111] Using the methods described above, companies can assess, and ultimately disclose, their exposure to the physical risks of climate change. As the case studies demonstrate, private companies and others are already successfully employing available climate tools and data to generate critical information to inform their own decision-making and that of regulators.

Sincerely,

Susana Camargo
Marie Tharp Lamont Research Professor, Ocean and Climate Physics
Lamont-Doherty Earth Observatory, Columbia University
[redacted]

Mark Cane
G. Unger Vetlesen Professor of Earth and Climate Sciences, Emeritus,
Lamont Doherty Earth Observatory, Columbia University
[redacted]

[111] IPCC, *supra* note 3, at 4.

Eleonor Dyan Garcia
Fellow and Postdoctoral Research Scholar, Sabin Center for Climate Change Law
Columbia Law School
[redacted]

Cynthia A. Hanawalt
Senior Fellow and Associate Research Scholar, Sabin Center for Climate Change Law
Columbia Law School
[redacted]

Mark Hixon
Hsiao Endowed Professor of Marine Biology
University of Hawai'i
[redacted]

Radley Horton
Research Professor
Lamont Doherty Earth Observatory, Columbia University
[redacted]

Robert Kopp, Ph.D.
Professor, Department of Earth and Planetary Sciences
Rutgers University
[redacted]

Jason E. Smerdon
Research Professor, Lamont Doherty Earth Observatory, Columbia University
Co-Senior Director of Education, Columbia Climate School
Co-Director, Undergraduate Program in Sustainable Development, Columbia University
[redacted]

Donald J. Wuebbles, Ph.D.
Emeritus Professor, School of Earth, Society, and Environment
Department of Atmospheric Sciences, University of Illinois
[redacted]

Romany M. Webb
Deputy Director and Associate Research Scholar, Sabin Center for Climate Change Law
Columbia Law School
[redacted]

Attachments (4):

(1) Consolidated Edison, Climate Change Vulnerability Study (2019)

(2) Paul Smith, UNEP FI, The Climate Risk Landscape: A Comprehensive Overview of Climate Risk Assessment Methodologies (2021)

(3) David Carlin & Alexander Stopp, UNEP FI, The Climate Risk Landscape: 2022 Supplement (2022)

(4) Bureau of Reclamation, Final Environmental Impact Statement: Continued Implementation of the 2008 Operating Agreement for the Rio Grande Project, New Mexico and Texas (2016)