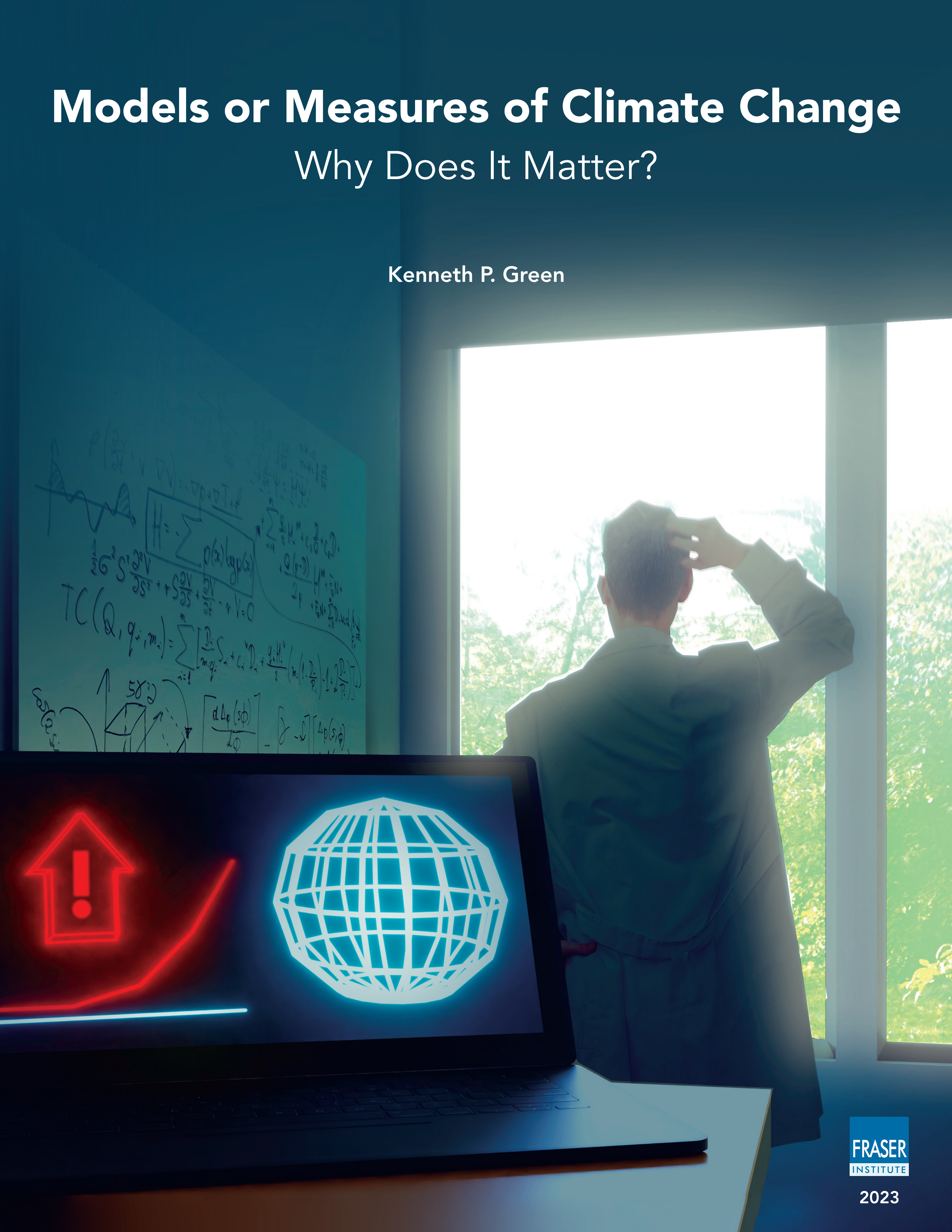
Models or Measures of Climate Change

Why Does It Matter?

Kenneth P. Green



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Executive Summary

Much of our understanding of anthropogenic climate change, and much of the debate over climate science and climate policy is based on information generated via mathematical modeling. Rarely, if ever, do we see much discussion of empirical measurements of climate change; global average temperature and sea level are rare exceptions. But empirical measurements of climate policy impacts, empirical measurements of changes that might, or might not, validate modeled projections of such climate changes, or empirical measurement of meteorological (weather) changes are scarce to non-existent in most media.

The list of modeled components of climate-change discourse is endless and model output information dominates nearly every element of discourse about the climate: modeling of how the climate works, modeling of what human activities influence the global climate, modeling of how human activities might influence the local climate, modeling of how climate changes manifest as weather or meteorological changes; modeling of how those activities might change over time, modeling of how public policies involving greenhouse gas controls might mitigate climate change; modeling of how people might respond to climate policies behaviourally (economically) and on and on.

At the same time, many of the input assumptions that are used to shape, or parameterize, such models are simply speculation about the future put to numbers. Modellers create scenarios and story-lines of future societal development, estimate greenhouse-gas emissions from those scenarios and story-lines, and plug those values into mathematical climate models that predict future warming, and the harms of that warming.

For those who believe that public policy—the enactment of rules and regulations that are, by their nature, coercive tools of governance—should be based on evidence of a calibre one might demand in a court of law to determine guilt or innocence of a crime, the almost complete reliance on model outputs is problematic. This is so because model outputs are not, in fact, empirical evidence of anything concrete in the physical world. The outputs of computer models are speculative simulations that portray how things might be, rather than how things actually are. It is a critical distinction between science and not-science, evidence and not-evidence.

And in fact, computer model outputs are often at odds with actual, empirically measured reality. This study examines only two such divergences within the broader subject of climate-change science and policy: the divergence between modeled estimates of the sensitivity of earth's atmosphere to greenhouse-gas enrichment, and the disagreement between modeled predictions and actual rates of greenhouse-gas enhancement.

As the study shows, the tendency of speculative mathematical climate models has been to over-estimate how sensitive the earth's atmosphere is to enrichment with greenhouse gases, when compared to estimates based on measurement of actual temperatures and greenhouse-gas enrichment. To put it simply, they over-predict atmospheric warming, and the derivative consequences that would flow from such warming. In addition, models used to predict the enrichment of the atmosphere with greenhouse gases have also been more extreme than reality has demonstrated. Combined, these two modeled parameters, the sensitivity of the climate and how much greenhouse gas would be emitted in the future, have generated the scenarios of extreme climate change that have dominated the discussion for the last 20 years.

The policy implications of the mismatch between model-based and measurement-based estimates of climate warming are fairly obvious. When compared with measurement-based estimates of climate sensitivity, model-based estimates appear to be running "too hot" and, as a consequence, policies to mitigate such changes are themselves likely running "too hot" and overly aggressive. Measurement-based estimates suggest an atmosphere less sensitive to greenhouse-gas enrichment. This would, in turn, suggest that less-aggressive efforts to mitigate greenhouse-gas emissions, perhaps also with longer time-horizons might suffice to protect the world from possible climate change.

Climate Change Models or Climate Change Measures—Why Does It Matter?

Every day, more and more aspects of the lives of Canadians—from the very small to the very large—are affected by mandatory public policies that, government argues, are absolutely necessary to manage the risks of man-made climate change. With a government that currently holds climate-change mitigation to be a central operating principle, Canadians are subject to ever more taxation, regulation, and myriad intrusions into how they choose to live their lives. Climate policies now affect where Canadians are allowed to live; the type of housing available to them and the materials of the construction; the transportation options available to them, and the technologies of the vehicles; the types of power available to them, and the fuels used to generate it; and through impact on the prices of goods and services across the Canadian economy, climate policies affect what products they wish to buy, which foods they wish to consume … the list is essentially endless and all-encompassing.

The biggest, most visible, of these mandatory policies are carbon taxes, of course, but they are only the most recent (and thinnest) layer of ice on the tip of a very deep iceberg of government regulatory mandates seeking to limit the emissions of greenhouse gases (GHG) in Canada. Some of these regulations may be direct and explicit involving, for example, the overt banning of the manufacture or use of various chemicals believed to aggravate climate change. Chlorofluorocarbons (CFCs) are one such class of chemicals. Powerful refrigerants, CFCs were originally banned under the Montreal Protocol because of their role in causing a thinning of the stratospheric ozone layer (which indirectly affects the climate). But CFCs (and several chemical cousins) are also estimated to be a powerful greenhouse gas in their own right. Other chemicals and chemical classes are in the cross-hairs of climate regulators as well, such as methane, sulphur hexafluoride, and more recently still, nitrous oxide. Straight-up bans on the production and use of various consumer products, like the recent bans on single-use plastics enacted by the Trudeau government, have also entered the realm of policy visible directly to the public. While couched as a ban on plastics, the program to create "zero plastic waste" by 2030 is part of government's net-zero emissions 2050 plan.

But these overt measures are still the minority. More often, government efforts to control greenhouse gas emissions are indirect, not-to-say "hidden", in measures that aim to cut back on the use of energy from fossil fuels in ways that include: vehicle fuel-economy standards, housing energy-efficiency standards, appliance efficiency standards, ambient-air quality standards (and “clean energy standards”), liquid fuel blending requirements and formulation standards, and more.

The vast, overwhelming motivation and rationale for these regulations and taxes are the outputs of statistical computer models of the climate and the risks of climate change. This is why it is important to understand that there is a crucial distinction between how climate is *modeled* and how it is *measured*. The latter method can in many cases be said to supply reasonably solid information on which to base laws and regulations, while the former can only be deemed speculation: useful, perhaps, in academic discourse, but not in the formation of public policy. If we confined our attention to measurements of observed patterns and trends in the climate system rather than model-generated projections of the distant future, the case for policy action would become much less pressing.

Contrary to popular narratives that focus on extremes of temperature and weather phenomenon, and the emission of greenhouse gases, the most important climate variable *from a public policy or “what should we do” standpoint* is neither the measured value (nor the modeled value) of the actual temperature change in the atmosphere over time. It is also not the measured value, or modeled value, of the physical rise in sea level seen since the end of the little ice age in the mid-nineteenth century. In fact, the most important variable from the perspective of public policy is not any of those related to visual manifestations of climate change, such as the measured value of changes in hurricane strength since 1850; the extent of arctic sea ice since 1950; polar bear populations in the Arctic; or the extent of ice in the Antarctic.

From a public policy standpoint, the most important variable in discussions of climate change is the climate sensitivity—that is, how sensitive the climate is to man-made emissions of greenhouse gases. This is most important because the emissions of greenhouse gases are about the only thing we have significant direct control over. And we don’t have much of that. The absolute concentration of greenhouse gases in the atmosphere, and trends over time are also important, and we will get to them following the discussion of climate sensitivity.

Climate Sensitivity—Perhaps the Most Important, Least-Understood Metric in the Climate Change Debate

Climate sensitivity is, arguably, the most policy-relevant variable in the climate debate for a simple reason: if the climate is largely insensitive to additional increments of the man-made greenhouse gases (GHG), then aggressive GHG control policies are clearly not needed, and cannot be justified as protecting human life or property. Further, if the climate is relatively insensitive to the greenhouse gases, then the level of greenhouse gas emissions of humanity past, present, or future, also have considerably less relevance than they have been recently accorded.

If, by contrast, the climate is highly sensitive to the enrichment of the greenhouse gases, some level of GHG control policies might well be warranted. And understanding the climate sensitivity, along with just how potent a particular gas might be at influencing the global temperature would allow for targeted and calibrated control of the most potent gases, making for the most focused, efficient climate policy.

The discovery of the influence of greenhouse gases on the atmosphere took place over about 350 years. The following brief history can be found on the website of the University Center for Atmospheric Research (UCAR, 2023) (paraphrased by author).

1640 Flemish alchemist Johann Baptista van Helmolt discovers that air is a mixture of gases, and studies carbon dioxide, which he called "the spirit of wood," because it comes off burning wood.

1754 Joseph Black, a medical student in Edinburgh, figured out how to measure carbon dioxide.

1824 Jean-Baptiste Fourier a mathematician working for Napoleon, described how the greenhouse gases in the atmosphere trapped heat near the surface of the earth, rendering it warmer than it would be as an uninsulated ball hanging in space.

1856 Eunice Foote, an American Scientist, discovered carbon dioxide and water vapour cause air to warm in sunlight.

1859 John Tyndall, a British physicist, put the finger on carbon dioxide, ozone, and water vapour as the heat-trapping culprits that kept us warm.

1896 Svante Arrhenius, a Swedish chemist who gets disproportionate recognition in this process, observed that burning coal released CO_2 into the air, and speculated that it would warm up the planet.

The list above is the history of the researchers who figured out that carbon dioxide, understood today to be the second most important "greenhouse gas" after water vapour, influences the climate. But understanding of the policy-relevant question, "Yes, but how big is the influence?" began with Svante Arrhenius, in the journal, *Philosophical Magazine and Journal of Science*, in which he wrote (referring to carbon dioxide as carbonic acid):

> One may now ask, how much must the carbonic acid vary according to our figures, in order that the temperature should attain the same values as in the Tertiary and Ice ages respectively? A simple calculation shows that the temperature in the arctic regions would rise about 8° to 9° C., if the carbonic acid increased to 2.5 or 3 times its present value. In order to get the temperature of the ice age between the 40th and 50th parallels, the carbonic acid in the air should sink to 0.62—0.55 of its present value (lowering of temperature 4°–5°C.). (Arrhenius, 1896: 268)

The whole metric of "2 × CO_2", that is a doubling of CO_2 from pre-industrial levels came from Arrhenius's original framing. If CO_2 levels were to double from its level in 1896, Arrhenius calculated, the climate would warm by somewhere between 4° to 5° C (which, for the imperially-minded, would be around 7.2° to 9° Fahrenheit).

Model-Based Estimates of Climate Sensitivity

Throughout the modern era, attempts to estimate the warming effect of doubling the level of CO_2 in the air have primarily been based on running climate models, and the range of results has generally been lower than Arrhenius' estimate. This paragraph is from the technical summary of the *Sixth Assessment Report* ("AR6") from the Intergovernmental Panel on Climate Change (IPCC):

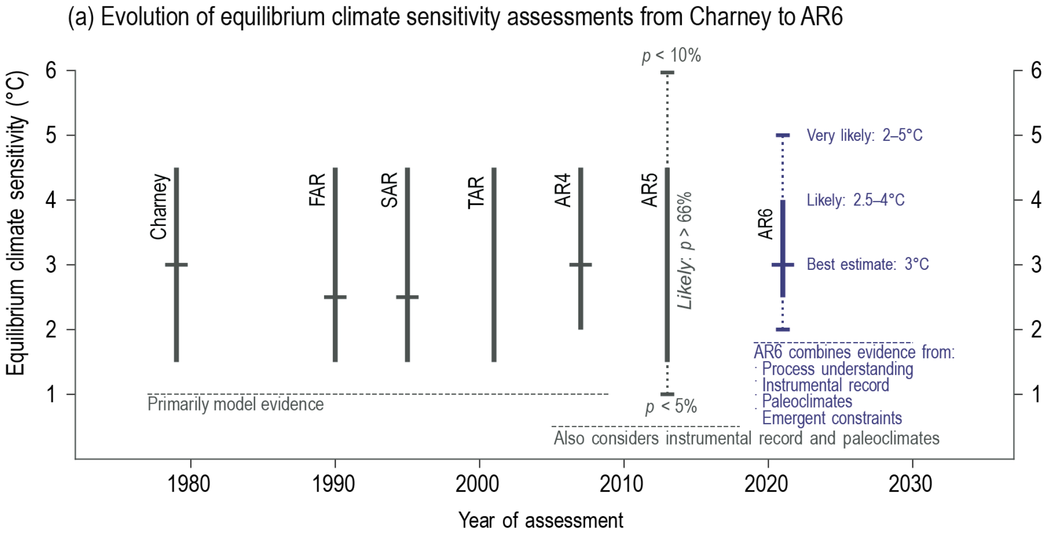
> Since AR5 [the Fifth Assessment Report, of 2014], substantial quantitative progress has been made in combining new evidence of Earth's climate sensitivity, with improvements in the understanding and quantification of Earth's energy imbalance, the instrumental record of global surface temperature change, paleoclimate change from proxy records, climate feedbacks and their dependence on time scale and climate state. A key advance is the broad agreement across these multiple lines of evidence, supporting a ***best estimate of equilibrium climate sensitivity (ECS) of 3°C, with a very likely range of 2°C to 5°C. The likely range of 2.5°C to 4°C is narrower than the AR5 likely range of 1.5°C to 4.5°C***. (IPCC, 2021: pTS-57; emphasis mine)

Equilibrium Climate Sensitivity (ECS) estimates how much the earth's surface will warm after doubling the amount of CO_2 in the air, after enough time has elapsed for the air, oceans, and land surface to adjust. It is usually reported as a range with a central "best" estimate. The figure below (figure 1) summarizes the historical ECS ranges that have been reported in major research assessments since climate modeling began in seriousness around 1980. This includes reports of the Intergovernmental Panel on Climate Change over time: the *First Assessment Report*, or FAR, through the *Sixth Assessment Report*, or AR6, and a predecessor report by the US National Academies of Science called the *Charney report* (NRC, 1979).

The vertical solid bars in figure 1 show the likely ECS range. The cross bars show the central best estimate. The dashed lines, which were introduced with the Fifth Assessment report, represent the extreme possibilities of climate sensitivity assessed as plausible by the IPCC. Note that the term "Very Likely" applied to the dashed lines is not based on physical theories or statistical tests but on the subjective judgment of the authors of the IPCC report.

Another interesting observation from this figure is that over the decades, the IPCC's estimates of climate sensitivity have not changed much, nor has the high end diverged much from Arrhenius' original estimate.

Figure 1: Estimates of climate sensitivity from IPCC's 2021 Assessment Report on the Physical Basis of Climate Change (IPCC, 2021)



Note Figure key as published (limited to the chart shown): Figure TS.16 | a) Evolution of equilibrium climate sensitivity (ECS) assessments from the Charney Report through a succession of IPCC Assessment Reports to AR6, and lines of evidence and combined assessment for (b) ECS and (c) transient climate response (TCR) in AR6. In panel (a), the lines of evidence considered are listed below each assessment. Best estimates are marked by horizontal bars, likely ranges by vertical bars, and very likely ranges by dotted vertical bars. Note that for the ECS assessment based on both the instrumental record and paleoclimates, limits (i.e., one-sided are given, which have twice the probability of being outside the maximum/minimum value at a given end, compared to ranges (i.e., two tailed distributions) which are given for the other lines of evidence. For example, the extremely likely limit of greater than 95% probability corresponds to one side of the very likely (5% to 95%) range. Best estimates are given as either a single number or by a range represented by grey box. Source: IPCC, 2021: fig. 16.

Measured Estimates of Climate Sensitivity

Empirical data about the climate is extremely difficult to gather at a scale directly relevant to assessing the global climate. Although many measurement systems exist today, including satellites, robotic ocean floats, and extensive networks of thermometers at the earth's surface, piecing together reliable measurements back to the 1800s or earlier is very difficult. That being said, one can assess climate sensitivity, in a "more" empirically grounded manner than is conventionally done using statistical models, by using long-term real-world data of climate warming and greenhouse gas emissions.

Climate researchers Nic Lewis and Judith Curry (Lewis and Curry, 2014), first attempted to estimate climate sensitivity in a more empirical way by correlating actual observed changes in greenhouse gases in the atmosphere with observed temperature changes over time. The Lewis and Curry approach to estimating the earth's climate sensitivity has generally concluded that the climate is less sensitive to greenhouse-gas enrichment than is estimated by the models of the IPCC.

This is the Abstract from Lewis and Curry 2014 in the peer-reviewed journal, *Climate Dynamics*. (Note that the "K" in the temperature readings stands for degrees on the Kelvin scale, which are the same as degrees on the Centigrade scale.)

> Energy budget estimates of equilibrium climate sensitivity (ECS) and transient climate response (TCR) are derived using the comprehensive 1750–2011 time series and the uncertainty ranges for forcing components [eg., greenhouse gas emissions] provided in the Intergovernmental Panel on Climate Change Fifth Assessment Working Group I Report, along with its estimates of heat accumulation in the climate system. The resulting estimates are less dependent on global climate models and allow more realistically for forcing uncertainties than similar estimates based on forcings diagnosed from simulations by such models. Base and final periods are selected that have well matched volcanic activity and influence from internal variability. Using 1859–1882 for the base period and 1995–2011 for the final period, thus avoiding major volcanic activity, median estimates are derived for ***ECS of 1.64 K and for TCR of 1.33 K. ECS 17–83 and 5–95% uncertainty ranges are 1.25–2.45 and 1.05–4.05 K; the corresponding TCR ranges are 1.05–1.80 and 0.90–2.50 K***. Results using alternative well-matched base and final periods provide similar best estimates but give wider uncertainty ranges, principally reflecting smaller changes in average forcing. Uncertainty in aerosol forcing is the dominant contribution to the ECS and TCR uncertainty ranges. (Lewis and Curry, 2014: Abstract; emphasis mine)

In simpler language, Lewis and Curry are using the estimated greenhouse-gas forcings—a variety of physical forces that can alter the climate—calculated by the IPCC—mostly a measure of carbon dioxide—but comparing them to actual temperature changes measured (mostly) over the same period. (The Transient Climate Response, or TCR, is a shorter-term metric of climate sensitivity). The key point, somewhat buried in the Abstract, is this: "The resulting estimates are less dependent on global climate models and allow more realistically for forcing uncertainties than similar estimates based on forcings diagnosed from simulations by such models".

Lewis and Curry updated these early findings in 2018 (Lewis and Curry, 2018), when new data became available about the actual uptake of heat by the oceans extending through 2016. In this later analysis, Lewis and Curry find that climate sensitivity, as assessed by comparing measured values of actual atmospheric heating and measures of atmospheric greenhouse-gas concentrations, was even lower than their initial estimations in 2014. In their 2018 study, Lewis and Curry found: "Using an 1869–82 base period and a 2007–16 final period, which are well matched for volcanic activity and influence from internal variability, medians are derived for ECS of 1.50 K (5%–95% range: 1.05–2.45 K) and for TCR of 1.20 K (5%–95% range: 0.9–1.7 K)" (Lewis and Curry, 2018: Abstract). They note that these estimates are not only lower in the mean, they have much lower upper bounds than those from a predecessor study using AR5 data ending in 2011.

The key take-away here is that, according to the findings of Lewis and Curry using an empirical approach to measuring climate sensitivity, the computer models used by the United Nations Intergovernmental Panel on Climate Change run hot. They suggest an atmosphere more sensitive to greenhouse-gas enrichment than can be seen from studies that actually analyze the physical response of the climate.

What Do We Know about Atmospheric Greenhouse Gas Emissions as a Modeled Rather than Measured Value?

The second most important variable in discussions of climate change—again *from a public policy perspective*—is how much GHG has been, is being, or will be emitted by humanity into the atmosphere within a time period that can be influenced via public policy. One of the most recent studies to examine this question is IPCC Baseline Scenarios Have Over-Projected CO_2 Emissions and Economic Growth, published in 2021 in the Open Access Journal, *Environmental Research Letters* (Burgess, Ritchie, Shapland, and Pielke Jr, 2021).

The Burgess study, co-authored by climate policy scholar Roger Pielke Jr, formed, in his assessment, "the most rigorous evaluation to date of how key variables in climate scenarios compare with data from the real world (specifically, we look at population, economic growth, energy intensity of economic growth and carbon intensity of energy consumption)" (Pielke, 2020). And the comparison of real-world trends shown in the Burgess study is not flattering to the IPCC's models.

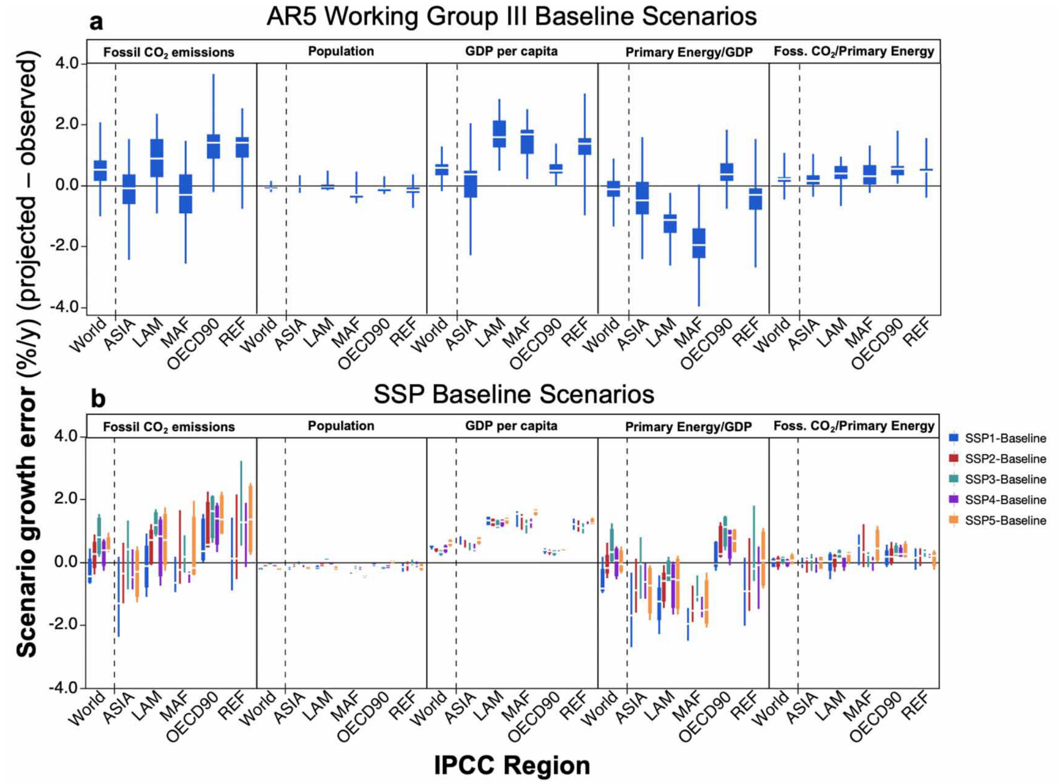
Figure 2 (from the Burgess study) shows how modeled estimates of 5 variables compare with measured data of the same variables. The variables are:

- Fossil CO_2 emissions;
- Population;
- GDP per capita;
- Primary energy/GDP (a measure of energy intensity); and
- Fossil CO_2 emissions/unit of GDP (a measure of emissions intensity).

The top panel in this figure shows estimates of Fossil CO_2 emissions, Population, GDP per capita, Primary Energy/GDP, and Fossil CO_2 emissions per unit of primary energy from the UN IPCC's *Fifth Assessment Report* of 2014. The second panel shows predictions for those same factors based on a somewhat different modeling scenarios adopted by the IPCC in 2017.

What is apparent, looking left to right at both panels a and b, is how great the variance of modeled estimates are from the actual measured data for the different variables seen in each panel, where the "0" line would be the baseline of the measured data in each panel against which the models were compared. The modeled estimates of GHG emissions, and GDP/capita are both well above actual measured data on these trends.

Figure 2: Comparisons in average annual growth rates between (a) AR5 and (b) shared socioeconomic pathways (SSP) baseline scenarios (2005–2017).



Notes (from original publication): "Boxes represent 25th to 75th percentiles (white dashes indicate medians). Lines above and below the boxes represent the full (min-max) range".
Source: Burgess, Ritchie, Shapland, and Pielke Jr., 2020: fig. 2.

Thus, in the first panel of both sections a and b, we can see that modeled estimates of Fossil CO_2 emissions are most often significantly higher than their measured comparator of data from 2005 to 2017. In panel 3, we see the same for GDP per capita: most *models* show higher estimates GDP/capita than *measured* data would suggest. In panel 4, we see that most models err on the side of under-predicting growth in Primary energy consumption/unit of GDP, and in panel 5, we see that most models seem to overestimate the trend in emissions of Fossil CO_2 per unit of primary energy produced.

A study of climate-model predictive skill by Zeke Hausefather and his colleagues in 2019 observed that, while historic climate models had reasonable predictive skill in modeling temperature change as it relates to climate forcings (by the greenhouse gases), they were also driven by predictions of greenhouse-gas emissions that were too high: "Most of the historical climate model projections overestimated future CO_2 concentrations, some by as much as 40 ppm over current levels, with projected CO_2 concentrations increasing up to twice as fast as actually observed" (Hausefather, Drake, Abbott, and Schmidt, 2019).

Why We Should Prefer Climate Measures to Climate Models in Public Policy Development and Construction

Why should we prefer more measured metrics for developing public policy rather than rely on what often appear to be far more detailed, and more diverse modeled metrics of a phenomenon such as man-made climate change? The short answer is, public policy is a quasi-legal instrument in which the force of government is brought to bear against people engaging in certain conduct that has been determined to be harmful to themselves or to others. That determination, for those who believe in the need for legal processes to be based in empirical reality—that is, a system of evidence and reason—means that the evidence should consist more of measures, and less of models (or not at all).

To elaborate, let us explore what public policy is, according to a few popular definitional authorities. *Merriam-Webster* succinctly (even tersely) defines public policy as "government policies that affect the whole population" (Merriam-Webster, 2022: *s.v.* Public Policy). The *Canadian Encyclopedia* is a bit more thorough, defining it thus:

> Public Policy generally denotes both the general purpose of government action and the views on the best or preferred means of carrying it out; more specifically it refers to government actions designed to achieve one or more objectives. "Policy" can have at least 2 distinct meanings: it can refer both to how something is done (rules and procedures), which may be called administrative policy, or to what is being done, eg, substantive programs. Studies of public policy often employ both meanings. In order to make various actions more coherent, governments usually formulate major priorities that form the basis of general policies, eg, social, economic and foreign policy, which in turn encompass more particular sectoral policies, eg, trade, police, health care, agriculture. (Bernard, 2014: *s.v.* Public Policy)

The *Legal Dictionary* defines it this way:

> The term "public policy" refers to a set of actions the government takes to address issues within society. For example, public policy addresses problems over the long-term, such as issues with healthcare or gun control, and as such, it can

> take years to develop. Public policy addresses issues that affect a wider swath of society, rather than those pertaining to smaller groups. (*Legal Dictionary*, 2019: *s.v.* Public Policy)

As one can see, definitions of public policy are relatively consistent across political perspectives, and transcends specific issues as well, in this case, climate change. The "Climate Reality Project", a climate-policy advocacy group defines public policy (in its *Government 101*) as "actions taken by any branch of the government, which includes laws, rules, regulations, executive orders, and legal precedents" (Climate Reality Project, 2020). They further explain that (US) federal law, regulations, and executive orders all constitute types of public policy.

For a more protracted definition, I recommend pages 1–34 of J.E. Anderson's *Public Policymaking: An Introduction*. Anderson puts some flesh on the bones of what is meant by "public policy", starting from "whatever governments choose to do or not to do" and traveling all the way to actions by public officials that "enact statutes, issue executive orders or edicts, promulgate administrative rules, or make judicial interpretations of laws".

Again, the *Canadian Encyclopedia* hits this idea squarely:

> Many measures or means are often necessary to implement policy, and these are frequently controversial because they involve coercion or the threat of a penalty if they are not followed. In every instance, the measures involve resources (levied, borrowed or purchased, produced and consumed, accumulated, distributed, loaned or sold) and rules (bans, obligations, authorizations, permissions, rights and privileges to do or not to do something). (Bernard, 2014: *s.v.* Public Policy)

What all of these definitions have in common is that they frame "public policy" in a compulsory legalistic framework, to be expressed, eventually, in the form of governmental laws, rules, and regulations. This is important, because laws and regulations are coercive actions that, in the tradition of most Western systems of law, are supposed to be predicated upon "just cause" as shown by rigorous, legally admissible, and recognized evidence—empirical, or "hard" evidence, not circumstantial evidence. And circumstantial evidence is all that models can provide, by their nature.

Grounding public policy on the outputs of computer models is the difference between justifying a coercive action of government on evidence of harm compared to justifying a coercive action of government based on speculation of harm.

Conclusion

Regulations involving environment, health, and safety have proliferated massively since the 1970s. Climate regulations, ostensibly, address all three of these issues. A respect for the concept of a society of laws suggest that these regulations should be based upon evidence of some sort, showing harms that are being done, to be ostensibly stopped through the action of a regulation. In the case of climate change (our focus here) mathematical models of climate sensitivity, and projected greenhouse gases—the two most policy relevant variables in the climate-policy debate—diverge sharply from empirically characterized reality.

In assessing the sensitivity of the climate to greenhouse gases (arguably the most important variable tying human action to climate change), models suggest sensitivity far above that of more empirically-based assessments. Likewise, in projecting greenhouse-gas emissions, the variable that would determine the urgency with which society might act to influence climate change, again, models (with their underlying assumptions) do not reflect reality: they reflect a scenario much worse than has been observed since their original publications (and predication of policy on their predictions). The process of forming public policy is a quasi-legal surrogate for the direct action of Parliament, enacting its directives by law. The evidentiary standards in setting public policy ought, therefore, be parallel in rigour to the processes by which we would develop, set, and enforce the laws of the land—that is, they should be evidence-based, rather than estimate-based. Over-reliance on climate models, as an example discussed here, results in policy recommendations and decisions that have been economically intrusive, highly contentious, and of dubious utility, while possibly occluding more effective and actionable solutions.

Examples of such more effective solutions might include strengthening coastal protections against rising tide levels, strengthening the capabilities and protection of water distribution systems to account for potential drought or flood-prone periods, improving flood-control systems and snow-management capabilities in Canada’s cities, improving forest-management techniques to adapt to potential changes in fire seasons or pest distributions, strengthening power systems needed to deliver sufficient affordable energy for heating and cooling of homes and businesses in the event of climate fluctuations, and more.

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About the author

Kenneth P. Green

Kenneth P. Green is a Fraser Institute senior fellow and author of over 800 essays and articles on public policy, published by think tanks, major newspapers, and technical and trade journals in North America. He holds a doctoral degree in environmental science and engineering from UCLA, a master's degree in molecular genetics from San Diego State University, and a bachelors degree in general biology from UCLA. Ken Green's policy analysis has centered on evaluating the pros and cons of government management of environmental, health, and safety risk. More often than not, his research has shown that governments are poor managers of risk, promulgating policies that often do more harm than good both socially and individually, are wasteful of limited regulatory resources, often benefit special interests (in government and industry) at the expense of the general public, and are almost universally violative of individual rights and personal autonomy. He has also focused on government's misuse of probabilistic risk models in the defining and regulating of EHS risks, ranging from air pollution to chemical exposure, to climate change, and most recently, to biological threats such as COVID-19. Ken Green's longer publications include two supplementary text books on environmental science issues, numerous studies of environment, health, and safety policies and regulations across North America, as well as a broad range of derivative articles and opinion columns. He has appeared frequently in major media and has testified before legislative bodies in both the United States and Canada.

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