

## Surrebuttal of Judith Curry, PhD

I submit this Surrebuttal Report to the Montana First Judicial District Court of Lewis and Clark County, with regards to Rikki Held et al. versus the State of Montana et al. in response to the Plaintiffs Rebuttal Expert Disclosures that relate to my expert Report that was previously submitted.

### Executive Summary

This Surrebuttal addresses comments from the Plaintiff's experts that were included in the Plaintiffs Rebuttal Expert Disclosures. The Rebuttals that reference my Report are mostly restatements of their own Expert Reports. The Rebuttals cite numerous main points of agreement with my Report. The Rebuttals also include many strawman arguments that misinterpret my statements, or make incorrect inferences about what I am saying or what they think my statements imply. There are also some substantive disagreements revealed by the Rebuttals that are clarified in the body of this Surrebuttal.

A brief summary of the Rebuttals relative to the four Sections of my Report:

- **Section 1:** none of the rebuttals challenge the data that I presented related to Montana's climate variability and change. Running, Whitman, Fagre and Trenberth challenge me on inferences that I did *not* make about the causes of the various trends and extreme weather/climate events.
- **Section 2:** Trenberth challenges me for emphasizing natural climate variability and uncertainty in assessing 21<sup>st</sup> century projections of climate change. The Byrons and van Susteren challenge me for my arguments regarding the underlying cause of the Youth Plaintiffs' psychological injuries, which in fact are in general agreement with van Susteren's ideas of pre-traumatic stress syndrome.
- **Section 3:** Jacobson challenges me for not agreeing with his Expert Report on renewable energy
- **Section 4:** Erickson challenges my interpretation of Montana's emissions and their role in actually influencing the climate of Montana

A summary of the cited points of agreement in the Rebuttals with my Report:

- "Dr. Curry's graphs (Figs. 1.1 and 1.2, taken from NCICS.org), in fact, properly display some of the trends occurring in Montana" - Running and Whitlock
- "During 2000–2007, the state experienced its highest number of very hot days since the extreme summer heat of the 1930s Dust Bowl era." – Running and Whitlock
- "The number of warm nights during the 2000s averaged about 50% higher than during the 1940s through the 1990s; the highest values on record occurred during the Dust Bowl era." – Running and Whitlock
- "It is also worth noting that Dr. Curry's claim that the Plaintiffs erroneously only consider data since 1950 and 1970 is simply not true. Both the above data and data in our September Expert Report go back much further than 1950." - Running and Whitman (JC)

note: this statement implicitly acknowledges that the Complaint did not consider earlier data)

- “Our September Expert Report, the Montana Climate Assessment, and the Greater Yellowstone Climate Assessment agree with the Curry report in observing that there have been no significant trends in precipitation over the last 120 years.” – Running and Whitman
- “The SWE (snow water equivalent) data from 2016-2022 (Curry report, Fig. 1.5) show snowpack variations that are related to year-to-year climate variability, such as the occurrence of strong La Niña conditions in 2018 that led to record snowpack in many parts of the state.” – Running and Whitman
- Looking at decadal averages, the current snowpack on April 1 is equivalent to that of the late 1930s, with both being the lowest of the last 800 years. – Running and Whitman
- “Dr. Curry argues that 1910 was a bad wildfire year in Montana and that fires have always been a part of nature. We agree . . .” - Running and Whitman
- “My first point in response is that both the 1930s and recent snow droughts, only decades apart, are the most severe in 800 years” – Fagre
- “Dr. Curry made the point that Glacier National Park’s glaciers were at their maxima at the end of the LIA about 170 years ago (Curry report p. 7). Although this is true, and an important context to consider when looking at rates of glacier loss . . .” - Fagre
- “Indeed many young people report that it isn’t the climate warnings that are the most stressful, it’s that, government leaders and the ‘other adults in the room’, despite the warnings, are still failing to adequately respond to them.” – van Susteren
- “Earth’s climate has always varied on multiple time scales, something emphasized in Dr. Curry’s report.” – Trenberth
- “It is important to understand that no one disagrees that extreme weather events have happened throughout human history.” - Trenberth

A number of strawman, irrelevant or generally erroneous arguments presented in the Rebuttals are enumerated below, which are either misinterpretations of what I said, or inferences about what I might have meant, or attempts to impose their own perspectives onto my Report:

- “Referring to an individual year of extreme conditions, as Dr. Curry has done in her expert report, therefore, is cherry-picking and irrelevant when analyzing climate change trends.” - Running and Whitman. There are two separate issues here – long term trends and extreme events which by definition refer to a specific time period. RW infer that my discussion of individual extreme events and years in some way is an attempt to refute the underlying increasing trend in surface temperatures that is clearly acknowledged in my Report.
- “The fact that abnormally warm temperatures were also experienced during the Dust Bowl era in the 1930s does not mean that climate change is not driving warmer temperatures today.” - Running and Whitman. Apart from RW’s misleading use of the term climate change, with the implication that all climate change is caused by emissions, RW’s statement does not relate to any statement in my Report.
- The Rebuttals of Byron and van Susteren criticize me for not accepting that the psychological injuries of the Youth Plaintiffs are real; I clearly state in section 2.3 that I accept that these psychological injuries are real.

- Several Rebuttals state that I ignores key scientific literature (stated by numerous experts in the rebuttals). I mostly rely on IPCC assessment reports and government supplied data. My failure to refer to other experts' preferred publications is largely associated with the fact that I am making different arguments with regards to the concerns of the Plaintiffs.
- Several Rebuttals state that I am not a published expert on [select] topic, having no publications in peer reviewed journals on [selected] topic. These statements neglect expertise beyond the academic ivory tower, which is obtained from real world experience of interacting with operational experts in areas such as electric utilities. These statements also neglect the common sense and broader perspectives that individuals from outside fields can bring to bear on a specific issue.
- Trenberth cites numerous statements and publications of mine circa 2005, in an attempt to argue that back then I supported what he regards as mainstream climate science, whereas now I am often on the other 'side' from Trenberth. There is a simple explanation: I've learned a lot over the past two decades. I regard my job as a scientist to continually assess the data, challenge assumptions and re-evaluate conclusions.

In the sections below, Surrebuttal is provided to the more substantive issues raised by:

1. Running and Whitlock
2. Fagre
3. Erickson
4. Byrons and van Susteren
5. Jacobson
6. Trenberth

## **1. Rebuttal of Running and Whitlock**

The most substantive portions of RW's rebuttal are addressed here:

- a) Arctic sea ice variations and cold air outbreaks and snowfall in the US
- b) Montana's historical wildfires
- c) emissions scenario RCP8.5

### ***a) Arctic sea ice Variations and cold air outbreaks and snowfall in the US***

RW state: "On page 21 of Dr. Curry's report, she notes Arctic outbreaks of cold air impacting Montana in 2019 and 2021. What Dr. Curry fails to mention is her own research that links such outbreaks to on-going changes in the Arctic due to climate change. Dr. Curry and her co-authors concluded in a 2012 paper: 'The results of this study add to an increasing body of both observational and modeling evidence that indicates diminishing Arctic sea ice plays a critical role in driving recent cold and snowy winters over large parts of North America, Europe, and east Asia.'

The cited quote from the 2012 paper that I co-authored actually seems to work against their overall argument; my paper states that less Arctic sea ice is expected to *increase* snowfall over North America (and thus can't explain any decreases in Montana's snowfall). Nowhere in my

report do I state that cold air outbreaks in Montana refute observations that Montana's climate is overall warming.

### ***b) Montana's historical wildfires***

RW present a convoluted argument to diminish that fact that 1910 was the worst fire in Montana history, by claiming that during 2020 more area (than the 1910 fire) overall burned for the entire western U.S. RW's argument with regards to the 1910 Montana fire versus the aggregate fires in the western U.S. during 2020 compares one big, local apple and with a large number of smaller oranges spread over a broad region.

In attributing the causes of wildfires in the western U.S, disentangling the slow creep of global warming, interannual to multi-decadal natural climate variability, land use changes, and forest management is far from straightforward. A longer-term perspective on variability and causes of wildfires in the western US is provided in a study<sup>1</sup> that concludes:

“Since the late 1800s, human activities and the ecological effects of recent high fire activity caused a large, abrupt decline in burning similar to the LIA fire decline. Consequently, there is now a forest “fire deficit” in the western United States attributable to the combined effects of human activities, ecological, and climate changes. Large fires in the late 20th and 21st century fires have begun to address the fire deficit, but it is continuing to grow.”

### ***c) Emissions scenario 8.5***

RW seem to implicitly accept my statements about RCP8.5 being an implausible emissions scenario, by making the defensive claim that “Our Expert Report, and Plaintiffs’ Complaint, do not rely Exclusively on RCP8.5 Emissions Scenario.”

Nevertheless, RW make many comments about RCP8.5 that reflect an outdated understanding. After defending the use of the RCP8.5 emissions scenario, they finally admit that “it is still a possible one.” They tacitly admit that nearly all of their analyses (but not “exclusively”) rely on what even they regard to be a barely possible emissions scenario. They seem unaware that the scenarios and policy making communities (notably the COP26, 27) have moved on from RCP8.5, and are focusing on RCP4.5 as a baseline scenario.

## **2. Rebuttal of Fagre**

The most substantiative portion of Fagre's Rebuttal is addressed here:

- a) interpretation of the percent losses of glacier area in Glacier National Park

### ***a) Interpretation of the percent losses of glacier area in Glacier National Park***

Fagre makes the following statement: “Glacier loss rates are calculated by Dr. Curry relative to glacier area at the end of Little Ice Age (LIA, ~1850) for each period to demonstrate that there is reduced loss rates in recent decades. However, her assessment is misleading because comparing the amount lost from 1998-2015 to the original LIA area overlooks the geometry of shrinkage.

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<sup>1</sup> <https://www.pnas.org/doi/10.1073/pnas.1112839109>

Even a large percent loss rate of tiny glaciers in recent times will be a small fraction of the original glacierized area is therefore deceptive. Thus, changes in percent should take into consideration the prior loss and normalize the new loss to this history. In absolute numbers, glacier retreat, even when accelerating, will have less area of ice to lose for each increment of climate forcing.”

Fagre’s claim obscures a simple calculation. Consider a pie. It took 30 years to eat half (50%) of the pie, then 25% of the pie was eaten in the subsequent 30 years, leaving 25% of the pie remaining. Twice as much pie was eaten during the first 30-year period than during the second year period. Fagre’s calculation implies that the rate of pie eating was the same during the second 30-year period as during the first 30-year period. I personally don’t think his way of calculating this is useful for understanding when the glaciers did most of their melting.

The main point of my calculation was to emphasize that 50% of the glaciers disappeared between the period 1850 and 1966 (which Fagre does not dispute). The period prior to 1966 was before fossil fuel emissions became large and during a period when climate model simulations both with and without anthropogenic greenhouse gas forcing produced essentially the same climate – it wasn’t until about 1980 when the so-called natural climate simulations diverged from climate model simulations that included human anthropogenic effects. Hence you cannot justify blaming the substantial early melting of the glaciers on fossil fuel emissions.

### **3. Rebuttal of Erikson**

The most substantive portions of Erikson’s Rebuttal are addressed here:

- a) whether Montana’s emissions are significant and meaningful
- b) status of global cooperation to address climate change
- c) relevance of Montana’s exported fossil fuels and related products
- d) renewable energy and geopolitical risks

#### ***a) Whether Montana’s emissions are significant and meaningful***

Erikson claims that “Montana’s greenhouse gas emissions are significant and meaningful.”

Erikson does not present an actual argument that Montana’s 0.09% contribution to emissions is meaningful to either the global or local climate. Any amount of CO<sub>2</sub> emissions is meaningful in context of certain political arguments, but it is not meaningful to the actual climate. The math is simple: for an expected 2°C warming by 2100 relative to the late 19<sup>th</sup> century, there is 0.9°C remaining (we have already warmed 1.1°C). Calculate  $0.9^{\circ}\text{C} \times 0.0009 = 0.0008^{\circ}\text{C}$  reduction in the expected warming by eliminating Montana’s emissions – a miniscule and immeasurable number. Even if the emissions number is multiplied by 5 (see subsection c below), this is still an exceedingly small number.

#### ***b) Status of global cooperation to address climate change***

Erikson states: “But these statements misrepresent the nature and status of global cooperation to address climate change. Nations of the world have already committed to pursue net zero

greenhouse gas emissions, and they have based their combined efforts in longstanding agreements on the principles of “widest possible cooperation” and globally shared responsibility.”

Well, this is a nice idea in principle. However, the COP27 highlights that this simply isn't happening. The ‘emissions gap’ – the gap between promised emissions reductions and what is actually happening with regards to emissions – is widely and increasingly decried by UN officials. And this is not to mention that the promised emissions reductions fall far short of actually achieving net zero emissions. With more than 50% of its electricity from renewable energy, Montana is more than doing its part in terms of near-term UN goals, particularly in comparison with most other U.S. states and the largest emitter (China).

### ***c) Relevance of Montana's exported fossil fuels and related products***

Erikson states that “total carbon dioxide emissions associated with Montana's fossil-fuel-based economy are about five times higher than the figures used by Dr. Curry and Dr. Anderson (accounting for indirect effects of fossil fuel exports).”

While I do not dispute Erikson's calculation, I dispute its relevance to assessing fossil fuels used by Montana. If Montana were to cease exporting fossil fuels, its customers (including the steel industry) would seek other sources of coal that are most likely dirtier than Montana's coal. And Montana would lose the economic benefit of making the sale. About 6 years ago, I consulted for an electric utility company located on the shore of one the Great Lakes, which supplied coal that was needed for coking and smelting in support of the manufacture of steel. They emphasized that directly burning coal was the only fuel that would allow steel to be cost effectively produced in the U.S. and emphasized that they purchased exceptionally high-quality coal from Montana.

### ***d) Geopolitics and renewable energy risks***

Erikson states: “Geopolitical risks do not absolve Montana from reducing fossil fuel production or emissions. Russia's war on Ukraine has increased the need and urgency to transition away from fossil fuels, in part to avoid the type of energy price spikes seen in recent months.”

Erikson misunderstands why Europe's fuel supply is currently compromised, posing great risks to its economy and the health and safety of its citizens. In its zeal to reduce emissions and increase renewable energy, Europe stopped mining coal, did not frack for natural gas, and shut down many nuclear power plants. This transition away from producing fossil fuel and nuclear energy was enabled by importing gas and coal from Russia. As a result of this strategy over the past decade and the Ukraine war, Europe now finds itself with insufficient fuel. Further, many European countries are not too enthusiastic about embracing a renewables only strategy in light of Germany's adverse experiences and skyrocketing energy costs.

## **6. Rebuttal of Byrons and van Susteren**

The most substantial portions of Byron's and van Susteren's Rebuttal are addressed here”

- a) triggers for the psychological injuries of the Youth Plaintiffs

Byrons' Rebuttal states: "Dr. Curry's contention that the psychological and emotional impacts of climate change are due to "apocalyptic climate change rhetoric" in the media and classroom, rather than climate change itself, is contradictory to the vast preponderance of medical literature and evidence discussed in our September Expert Report."

What is missing in medical literature on this issue is a clear identification of the source of trauma that have triggered these psychological and emotional impacts. The options are the post-traumatic stress of actually experiencing major, traumatic loss (few of the personal experiences of the Youth Plaintiffs qualify here) versus pre-traumatic stress syndrome regarding anticipation and expectation of future harm.

Byrons state: "Dr. Curry argues any psychological injuries related to climate change that children are experiencing is caused by the media, school curricula, or politicians, not the actual exposure to climate change impacts to these children." "Dr. Curry's argument completely ignores the personal experiences of individual children, including the Youth Plaintiffs here, and improperly looks for another source for the psychological injuries when the answer is already apparent."

The worst experience among the Youth Plaintiffs is arguably by Rikki, whose family lost some buildings on their property (not their home) plus some livestock in a wildfire. In context of the overall traumatic experiences that have been experienced by children in the U.S. (school shootings, family members being killed, gang violence, loss of home or school in a human-caused or natural disaster, etc), Rikki's trauma does not rank very high. The level of adversity experienced by the Youth Plaintiffs are well within the experiences of very many children from a variety of causes, and well within the historical experiences of children in Montana in response to extreme weather/climate events. All of these adverse experiences are unfortunate, but they are a part of life even in an affluent country such as the U.S.

The point of my Report is that psychological and emotional impacts of these children are more related to pre-traumatic stress than to post-traumatic stress. Conflating these two triggers for the psychologic injuries under "climate change" confuses the issue when trying to understand the root causes.

Van Susteren states: "No scientific research, however, supports her personal belief. In fact, the overwhelming scientific consensus is that young people's climate distress is based not only on an understanding of the science, but also on young people's personal experiences with climate change impacts."

This statement is belied by van Susteren's own work and statements on pre-traumatic stress syndrome in context of climate change:

- "Warnings about climate have made young people legitimately fearful, depressed, and angry. Many feel abandoned."<sup>2</sup>

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<sup>2</sup> <https://acamh.onlinelibrary.wiley.com/doi/full/10.1111/camh.12496>

- “We are also seeing *pre*-traumatic stress: a condition with the same characteristics as PTSD ...but that are triggered by the visions of *future* trauma.”<sup>2</sup>
- “But trauma can also arise from fears of future threats, giving rise to “pre-traumatic stress.”<sup>3</sup>
- “PTSD may also be diagnosed after indirect exposure to trauma, from reflecting on traumatic experiences that relatives or friends have endured or even, simply, from repeatedly hearing details of traumatic events.”<sup>3</sup>

My original Report sought to separate the influences on the Youth Plaintiffs’ psychological injuries from:

1. Actual experiences, with the information provided in Section 1 of my Report arguing that the experiences of the Youth Plaintiffs are not in any way unusual or attributable to human-caused global warming
2. Repeatedly hearing details of traumatic events, which Section 1 of my Report argues that are mis-attributed to human-caused global warming by the sensationalist media
3. Exaggeration of future threats from human-caused climate change, with apocalyptic rhetoric from politicians and the media, described in Section 2 of my Report.

My Report suggested that influences #2 and #3 are far greater causes of stress than #1, and that influences #2 and #3 are associated with apocalyptic rhetoric in the media as well as particularly apocalyptic and inappropriate materials that are targeting children and young adults.

All of the citations of the medical literature on this topic provided by the Byrons and van Susteren fail to refute in any way the fundamental logic of my argument regarding questions and hypotheses about the underlying trigger of the climate-related stress.

van Susteren states: “Given these facts, Dr. Curry’s report on these matters should be assessed in accordance with what they represent – a reflection of nothing more weighty than her personal opinion.”

My “personal opinion” on this issue has been informed by extensive discussions with one of the world’s leading military psychologists and experts on stress. Some insights from these discussions:

- The perspective from the Byrons and van Susteren is that of psychiatrists, who focus on illness. Broader perspectives are needed for this issue, including that from psychologists who focus on building health and resilience.
- Young people are experiencing anxiety (or pre-traumatic stress reaction) regarding climate change and future climate events, owing to the climate activist community (which includes van Susteren) who are broadcasting doomsday predictions and seeking to stir up emotional reactions and worries in people. The net effect is to increase neurotic worrying in many people,<sup>4</sup> which can indeed make people more vulnerable to negative stress reactions.

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<sup>3</sup> <https://blogs.bmj.com/bmj/2020/11/19/our-children-face-pretraumatic-stress-from-worries-about-climate-change/>

<sup>4</sup> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6196079/>



It doesn't require a medical degree to identify the limitations of the psychiatric-based approach used by Byrons and van Susteren to assess the broad problem of psychological injuries to young people associated with climate change.

Stress (past, present, future) is a part of life for all of us. What matters is how we think about it, how we appraise it, and how we see ourselves in relation to it. This normal way of dealing with stress has been perverted when dealing with climate stress by the apocalyptic rhetoric surrounding climate change and political manipulation of children.

## **5. Rebuttal of Jacobson**

The most substantive portions of Jacobson's Rebuttal are addressed here:

- a) Montana's current renewable energy environment
- b) criticisms of Jacobson's published analyses of 100% renewable systems
- c) assumptions about battery storage and hydro back up and storage

### ***a) Montana's renewable energy environment***

Jacobson claims: "The sum of all clean, renewable wind-water-solar) electricity generation in Montana as a percent of electricity consumption was 92.6%. Fossil fuels produced additional electricity such that the total generation compared with consumption exceeded 100%, with the difference being exported. Thus, before any real growth of solar PV and before even realizing Montana's full wind potential, the state already meets 92.6% of its electricity consumption with clean, renewable electricity generation, and 70% of this consumption already has a reliable source of backup (conventional hydropower)."

If you subtract the annual average electricity exported from MT from the total electricity produced by MT, and then assume that all exported energy is from fossil fuels, then you obtain renewable energy as providing 92.6% of MT's electricity. However, the inference that MT is almost there (92.6%) in terms of producing enough renewable energy for its internal consumption is incorrect. The claim about backup seems to double count hydropower both as a primary and backup source of power. This highly simplified analysis neglects seasonal variability in wind-water-solar power generation as well as weather-based intermittency and interannual climate variability. Simply put, in some situations MT is in a position to export a lot of electricity, and at other times when renewable generation is low, I would expect much less electricity to be exported and a large amount of fossil fuel-derived electricity to be needed.

Regarding solar power in Montana, Jacobson states: "Prof. Curry claims that the solar PV capacity will "never reach that seen in the more southern states." (Page 18.) However, this is simply not true. The National Renewable Energy Laboratory (NREL) map Prof. Curry provides clearly indicates that the solar resources in southern Montana are similar to those in parts of South Dakota, Iowa, Illinois, Indiana, Kentucky, and West Virginia." South Dakota, etc. are not regarded as southern states. Montana's relative lack of solar energy potential is based on the simple fact of Earth-Sun geometry and the tilt of the Earth's axis. This is elementary knowledge.

## ***b) Jacobson's published analyses of 100% renewable energy systems***

Jacobson claims that: "The ability of a future wind-water-solar energy system with hydropower and battery storage to keep the grid stable every 30 seconds for two years in the WECC grid, which Montana resides in, at low cost was demonstrated in the Jacobson et al. (2022a) paper."

Jacobson's paper is one in a series of similar papers that are basically academic exercises based on toy models that use numerous oversimplifications. In 2017, a large team of prominent clear energy scholars from respected US universities, think tanks and research labs published a paper in the Proceedings of the National Academy of Sciences<sup>5</sup> that savaged Jacobson's proposal. The paper's overarching conclusion:

"The authors claim to have shown that their proposed system would be low cost and that there are no economic barriers to the implementation of their vision. However, the modeling errors described, the speculative nature of the terawatt-scale storage technologies envisioned, the theoretical nature of the solutions proposed to handle critical stability aspects of the system, and a number of unsupported assumptions, including a cost of capital that is one-third to one-half lower than that used in practice in the real world, undermine that claim."

The most fundamental criticism is that Jacobson's proposal rests on impossible assumptions about hydropower.

Jacobson filed a \$10 million defamation suit against the lead author and the journal that published the critical article. Observers from within and outside of the scientific community condemned Jacobson's tactics as retribution against scientists for engaging in the scientific process of critically evaluating research.<sup>6</sup>

Experts from U.S. National Renewable Energy Laboratory (NREL) and Department of Energy recently published a report entitled "What we know and don't know about achieving a national scale 100% renewable electric grid."<sup>7</sup> The paper identified substantial technical and economic challenges that would need to be overcome to achieve 100% renewable electric power across the United States.

## **6. Rebuttal of Trenberth**

The most substantive portions of Trenberth's Rebuttal are addressed here:

- a) emissions scenario RCP8.5
- b) role of natural climate variability in the 21<sup>st</sup> century
- c) climate sensitivity to CO<sub>2</sub> and 21<sup>st</sup> century climate projections
- d) expectations for remaining within 2°C warming during the 21<sup>st</sup> century

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<sup>5</sup> <https://www.pnas.org/doi/10.1073/pnas.1610381114>

<sup>6</sup> <https://www.science.org/content/article/10-million-lawsuit-over-disputed-energy-study-sparks-twitter-war>

<sup>7</sup> <https://www.sciencedirect.com/science/article/pii/S2542435121001513>

***a) Emissions scenario RCP8.5***

Trenberth states: “Dr. Curry mis-states the IPCC, which does not prefer one emissions scenario over another. Rather, it evaluates a range of scenarios with different levels of risk for policy reasons. It is not the function of the IPCC to determine which pathway governments should choose for planning purposes.”

Trenberth is incorrect: I do not mis-state the IPCC. Trenberth’s own assessment of what the IPCC has done with regards to scenarios is incorrect – their assessment reports have heavily favored impacts associated with RCP8.5 (numerous analyses have counted the mention of the different scenarios in the IPCC reports). The IPCC is increasingly realizing that RCP8.5 is an implausible scenario, as per the statement from the AR6 WGI Chapter 1 that I included in my Report, which is repeated here:

“In the scenario literature, the plausibility of the high emissions levels underlying scenarios such as RCP8.5 or SSP5–8.5 has been debated in light of recent developments in the energy sector.”

The key point of relevance for this Complaint is that RCP8.5 is no longer being used in international (UN) policy making as reflected by the recent COP26, 27. With specific context of this Complaint, nearly all of the projections in the Complaints and from RW Expert Reports were based on RCP8.5.

***b) Role of natural climate variability in the 21<sup>st</sup> century***

Trenberth states: “Dr. Curry’s forthcoming book, which she cites as footnote 53 in support of her claim that a natural cooling period will be of greater magnitude than GHG forcing is not a peer reviewed scientific publication. This unsupported statement grossly overstates the possible role of natural variability and is at odds with IPCC and national climate assessments, which reflect the international and national consensus of the scientific community.”

Trenberth misstates what I actually wrote in my Report, which is reproduced here:

“The climate model simulations used in the IPCC AR6 include very limited scenarios of volcanic eruptions and solar variability. Further, the climate models have inadequate representations of solar indirect effects and multi-decadal to century-scale variations in the large-scale ocean circulations. All of the components of natural variability point to cooling during the period 2020 to 2050. Individually these terms are not expected to be large. However when summed, their magnitude approaches, or could even exceed, the magnitude of the emissions-driven warming for the next three decades.”

Further, Trenberth is wrong in his statements that purportedly represent the “international and national consensus of the scientific community.” In support of my actual statements in the preceding paragraph, the IPCC AR6 WGI Report (Cross Chapter Box 4.1) states:

“Given the unpredictability of individual eruptions, volcanic forcing is prescribed as a constant background loading in CMIP6 models (Eyring et al., 2016). This means the effects of potential large volcanic eruptions are largely absent from model projections, and few studies have addressed the potential implications on 21<sup>st</sup> century warming. One study considered future scenarios with hypothetical volcanic eruptions consistent with levels of CE volcanic activity (Bethke et al., 2017) under RCP4.5 and found that climate projections could be substantially altered. (Bethke et al., 2017) suggest that an eruption early in the 21<sup>st</sup> century could delay the timing of crossing 1.5°C global warming by several years. Clustered eruptions would have substantial impact upon GSAT [global surface air temperature] evolution throughout the century, and could have far-reaching implications, as observed for past eruptions.”

Cross Chapter Box 3.1 from the IPCC AR6 WGI Report provides assessment of how internal variability can obscure the underlying warming trend from CO<sub>2</sub>. Some text from my forthcoming book is provided below, including more recent publications:

“Studies using global climate models to assess the probability of decades in the 21<sup>st</sup> century being characterized by net cooling have mostly focused only on natural internal variability,<sup>64 65</sup> with one study that considers volcanic eruptions plus internal variability.<sup>66</sup> Volcanic-induced cooling becomes increasingly important in facilitating neutral or negative temperature trends on longer timescales, in conjunction with natural internal variability effects. Several studies have addressed the combination of internal and solar variability.<sup>67 68</sup> Apart from the wild-card of volcanic eruptions, the big uncertainty is solar indirect effects. The growing likelihood of a solar minimum of some magnitude during the mid-21<sup>st</sup> century emphasizes the need for a resolution to the debate over low versus high variability solar reconstructions, and improved understanding of solar indirect effects.”

<sup>64</sup> Nicola Maher et al., “Quantifying the Role of Internal Variability in the Temperature We Expect to Observe in the Coming Decades,” *Environmental Research Letters* 15, no. 5 (September 24, 2020): 054014, <https://doi.org/10.1088/1748-9326/ab7d02>.

<sup>65</sup> Thomas R. Knutson et al., “Prospects for a Prolonged Slowdown in Global Warming in the Early 21<sup>st</sup> Century,” *Nature Communications* 7, no. 1 (November 30, 2016), <https://doi.org/10.1038/ncomms13676>.

<sup>66</sup> Ingo Bethke et al., “Potential Volcanic Impacts on Future Climate Variability,” *Nature Climate Change* 7, no. 11 (November 2017): 799-805, <https://doi.org/10.1038/nclimate3394>.

<sup>67</sup> Nicola Scafetta, “Discussion on Climate Oscillations.”

<sup>68</sup> Frank Stefani, “Solar and Anthropogenic Influences on Climate: Regression Analysis and Tentative Predictions,” *Climate* 9, no. 11 (November 3, 2021): 163, <https://doi.org/10.3390/cli9110163>.

### ***c) Climate sensitivity to CO<sub>2</sub> and 21<sup>st</sup> century climate projections***

Trenberth states: “Dr. Curry’s statements at the bottom of page 11 of her report that the high sensitivity of certain climate models was not factored into the IPCC assessment results is wrong. The IPCC assessment did correct for the known high-biased models. Consequently, her statement that Table 2.1 values may be too high has no basis.”

Trenberth misinterprets my statement. Here is the actual text from my Report:

“Further, climate model simulations used in the IPCC AR6 to project the amount of warming in the 21st century (Table 2.1) are not providing the full range of scenarios of plausible climate outcomes. Two recent journal publications have found that climate models are too sensitive to increasing CO<sub>2</sub>, and that more likely values of warming are on the lower part of the very likely range in Table 2.1 (or even lower).”

Trenberth is correct in that “high sensitivity of certain climate models was not factored into the IPCC assessment.” However, he omitted to state that climate models with low values of sensitivity were also omitted, which is at the heart of the concern that I raised on page 11.

***d) Expectations for remaining with 2°C warming during the 21<sup>st</sup> century***

Trenberth states: “One misuse of the IPCC is that Dr. Curry’s Table 2.1 on page 10 gives global mean temperatures, not Montana mean temperatures. Montana’s mean temperatures are different than the global average (see Figures 3 and 5). Moreover, those global mean temperatures are not even for land, which are roughly doubled what is depicted in Table 2.1.”

Table 2.1 in my Report cites global mean temperature projections from the IPCC, and is clearly labeled as such. Chapter 10 of the IPCC AR6 WGI acknowledges that there is no simple recipe for making regional climate projections, and the IPCC AR5 Working Group II (WG II) regarded such projections to be a matter of basic research. The challenge for developing useful regional scenarios of climate change requires integrating carefully culled climate model simulations with historical data and process-based understanding. The IPCC AR6 refers to this as “the distillation of regional climate change information from multiple lines of evidence.”

Providing credible regional climate projections for Montana is well beyond the scope of my Expert Report. I have evaluated what is available in previous reports, and those projections are not something that I would recommend to my clients.

Trenberth states: “There is also currently no basis for Dr. Curry’s statements at the top of page 13 of her report that we are likely to be close to, or within, a 2°C temperature increase by 2100. Based on our present understanding of the climate system and emissions projections, we will likely pass through 2°C warming (as a global average temperature increase) above preindustrial temperatures during the 2050s unless substantive emissions reductions are adhered to and the elimination of fossil fuel greenhouse gas emissions really does become viable around 2050. Indeed, the October 27, 2022 United Nations Environment Programme Emissions Gap Report found that the current policies of nations will warm the world by 2.8°C (5.0°F) by 2100; if all current national emission-reduction pledges are also fully implemented, then the Earth will warm by 2.4-2.6°C (4.3-4.7°F) by 2100.”

While the word “close” is a subjective term, 2.4-2.6°C can be regarded as “close to” 2.0°C, particularly in context of the projections of 4°-5°C warming of only a few years ago. The UNEP projections are based on values of climate sensitivity that I have argued are too high, and do not adequately account for natural climate variability. Given the myriad uncertainties associated with

these projections, there is plenty of room for a broader range of scenarios than has been presented by the UNEP and certainly room for plausible scenarios less than 2.0°C.

Signed this 12<sup>th</sup> day of December, 2022

A handwritten signature in blue ink, appearing to read "Judith Curry". The signature is fluid and cursive, with a long horizontal stroke extending to the right.

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Judith Curry