Welcome to this week's presentation & conversation hosted by the **Canadian Association for the Club of Rome**, a Club dedicated to intelligent debate & action on global issues.

The views and opinions expressed in this presentation are those of the speaker & do not necessarily reflect the views or positions of CACOR.

2°C: Guardrail or Guide Rail to Disaster?

Our speaker today is Dr. Kent Peacock, Professor of Philosophy at U Lethbridge. He works in foundations of physics, logic, & philosophy of the environment. He has a strong interest in all matters related to climate & energy, & he is currently holder of a SSHRC Insight Grant to study "The Symbiotic Conception of Sustainability."

DESCRIPTION: The idea that 2°C is a safe guardrail for global heating was a guesstimate by an economist almost fifty years ago, and it had a sketchy scientific basis even at that time. The 2023 *State of the Cryosphere* report says unequivocally, "Two Degrees is Too High." The only hope of preventing catastrophic sea level rise, say the authors of this report, would be to cool the planet to a temperature anomaly of not much more than 1°C. In a year of bad news for the climate, no one wants to hear a prescription like this, but climate policy must be adjusted—quickly—to reflect this grim reality.

The presentation will be followed by a conversation, questions, & observations from the participants.

CACOR acknowledges that we all benefit from sharing the traditional territories of local Indigenous peoples (First Nations, Métis, & Inuit in Canada) and their descendants.

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2024 Jan 25 Zoom #181

2°C:
Guardrail—or Guide Rail to Disaster?

Kent Peacock
Department of Philosophy, University of Lethbridge

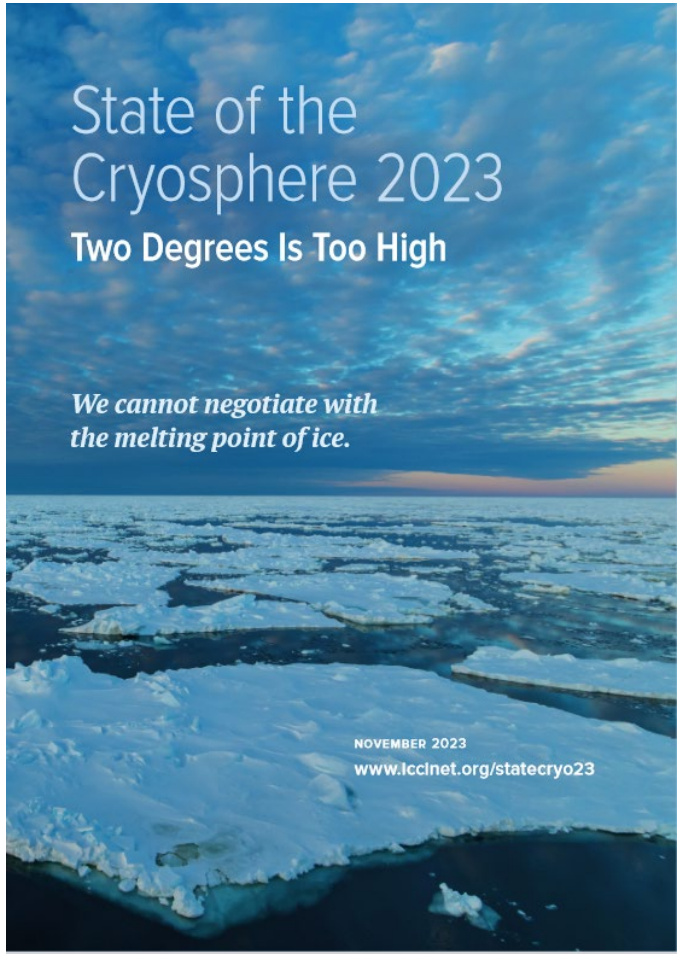
Canadian Association for the Club of Rome

January 25, 2024

NASA JPL

What Everyone Needs to Know…

- "A compelling number of new studies … all point to a threshold for both Greenland and parts of Antarctica well below 2°C, committing the planet to between 12–20 meters sea-level rise if 2°C becomes the new constant Earth temperature."
- This implies that 2°C is not a guardrail *beyond which* the effects of carbonization would become unacceptable.
- Rather, it is a point at which *climate catastrophe is guaranteed*.
- This report (and other results) imply that current climate agreements (based on staying within the 2°C limit and "aspirationally" holding to 1.5°C) are hopelessly inadequate.
  - This report (which came out just before COP28) has received *almost no notice or discussion in major media outlets*.
    - The Report, at https://iccinet.org/statecryo23/
    - Very clear review in *Carbon Brief*, at https://www.carbonbrief.org/qa-warming-of-2c-would-trigger-catastrophic-loss-of-worlds-ice-new-report-says/



This Is Not a New Idea

- Gavin L. Foster and Eelco J. Rohling, "Relationship between sea level and climate forcing by CO_2 on geological timescales", *PNAS* 110(4), 1209-1214, 2013.
  - "…accurately determining the long-term response of sea level to CO_2 forcing has significant implications for the long-term stabilization of greenhouse gas emissions (by natural processes or human activity) and for decisions about the "acceptable" long-term level of CO_2/warming. For instance, *our results imply that acceptance of a long-term 2°C warming [CO_2 between 400 and 450 ppm (46)] would mean acceptance of likely (68% confidence) long-term sea-level rise by more than 9 m above the present*. Future studies may improve this estimate…"
  - Indeed, future studies have only made the estimate higher.
- Note that this paper was published *before* the Paris Agreement of 2015, which set 2°C as the world's climate policy goal.

One of Many Warnings From James Hansen

- "The nonlinearity of the ice sheet problem makes it impossible to accurately predict the sea level change on a specific date. However, as a physicist, I find it almost inconceivable that BAU [Business As Usual] climate change would not yield a sea level change of the order of meters on the century timescale."
    - James Hansen, "Scientific reticence and sea level rise", Environmental Research Letters 2, 024002, 2007.
- Hansen and colleagues state that they are working on a paper to be entitled, "SLR in the Pipeline".
  - Watch for this!

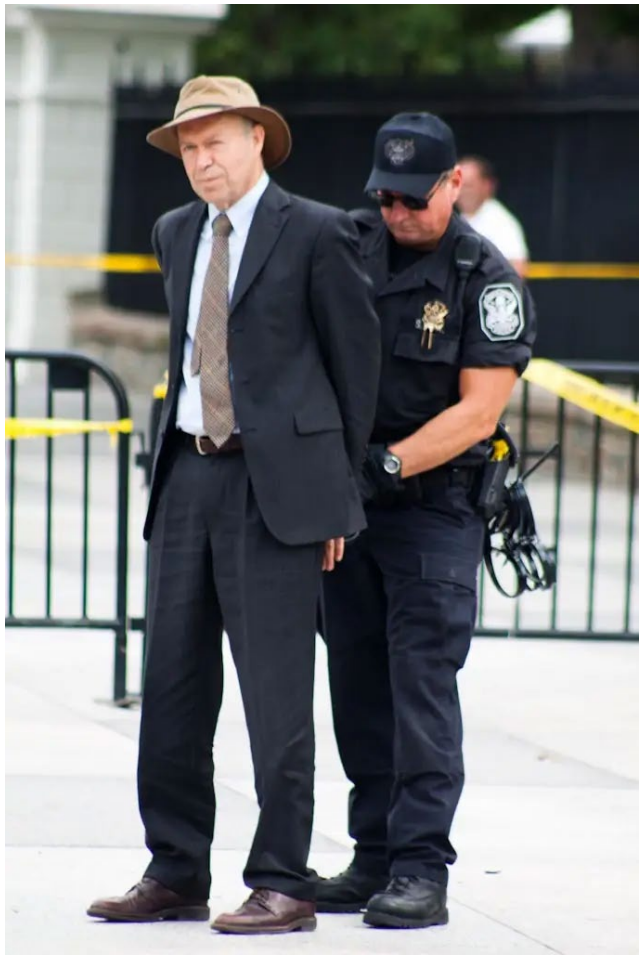


Image by PDTillman, Wikipedia, "James Hansen".

Hansen Sets the Bar High

- "The threat of a large sea level change is a principal element in our argument … that the global community must aim to keep additional global warming less than 1°C above the 2000 temperature [i.e., about 1.4°C above IPCC 1850-1900 baseline], and even 1°C may be too great. In turn, this implies a CO_2 limit of about 450 ppm, or less. Such scenarios are dramatically different than BAU, requiring almost immediate changes to get on a fundamentally different energy and greenhouse gas emissions path."
    - Hansen 2007.
- In 2008 Hansen and colleagues argued that climate policy should be aimed at reducing [CO_2] to no more than 350 ppm, "but likely less than that":
    - J. Hansen et al., "Target Atmospheric CO2 : Where Should Humanity Aim?" *The Open Atmospheric Science Journal 2,* 217-231, 2008.

Warning from a Glacier Whisperer

- "West Antarctic ice sheet and CO_2 greenhouse effect: A threat of disaster," J. H. Mercer, *Nature* 271, 26 January 1978, 321—5.
  - "If the CO_2 greenhouse effect is magnified in high latitudes, as now seems likely, deglaciation of West Antarctica would probably be the first disastrous result of continued fossil fuel consumption."
    - [Arctic amplification is now well-confirmed.]
  - "One of the warning signs that a dangerous warming trend is under way in Antarctica will be the breakup of the ice shelves on both coasts of the Antarctic Peninsula, starting with the northernmost and extending gradually southward."
    - Larsen A (1995), Larsen B (2002), …
  - Mercer also correctly predicted that the centre of WAIS (West Antarctic Ice Sheet) would begin to thin.

John H. Mercer
1922—1987

Mr. Guterres on Sea Level Rise

- Recently, António Guterres, Secretary General of UN, stated that seas may rise to "unthinkable" levels and threaten "a mass exodus of entire populations on a biblical scale".
- What risks of sea level rise do we actually face?

From Guardian, 14 Feb., 2023.

How Much Could Sea Level Rise?

- If all the ice in the world were to melt, it would lead to sea level rise of about 65-70 metres.
  - Greenland: about 7 metres.
  - Antarctica: roughly 58 metres (estimates less certain because they haven't found all the ice yet!).
  - Mountain glaciers and ice fields around the world make up most of the rest.
  - Some sea level rise due to thermal expansion—hard to estimate (depends on how warm the water gets) but it could be a few metres as well.

How Fast?

- To answer this key question, we have to understand a few basic facts about ice.
  - (This is not Glaciology 101, which I would not be qualified to teach, but more like Kindergarten level glaciology, which even a philosophy professor can understand.)
- We will see that in an important sense the question, “How fast?” is not relevant—there is absolutely no scope for delay.

Kinds of Ice

- For our purposes, there are three main kinds of ice in the world:
  - Ice on land (icefields, mountain glaciers, land-based ice caps).
  - Floating ice:
    - Sea ice
    - Ice shelves & tongues
  - Marine ice sheets:
    - This is the wild card, for reasons we need to understand.

Melting, By Land

- If land-based ice melts, it is simple—sooner or later the water ends up in the sea.
  - (Unless some evaporates and turns back into snow.)
  - (But melt rates can greatly exceed any possible evaporation/recondensation rate.)
- Melting of land-based ice is a major mechanism of mass loss in Greenland, especially in the summer.

Melting, By Sea

- If floating ice melts, it does raise the water level slightly.
  - (See NASA, Melting Ocean Ice Affects Sea Level – Unlike Ice Cubes in a Glass.)
- However, the melting of sea ice and ice shelves has at least three major effects on the earth system:
  - Open water absorbs much more solar radiation than ice (lower albedo, "whiteness").
    - Melting of sea ice is, therefore, one way in which *warming causes more warming*.
  - Ice shelves buttress the land-based and marine-terminating glaciers behind them, and when the shelves disappear, the glaciers can flow into the sea much faster—this *does* raise sea level.
  - Loss of sea ice and ice shelves may have disastrous (but still imperfectly understood) effects on marine biota.

Melting, *Below* the Sea

- Marine ice sheets are masses of ice jammed into basins going down well below sea level (kms below).
  - They often terminate in the open sea, exposing the base of the ice sheet to ocean currents.
  - If undisturbed they can remain stable for thousands of years, but there is much evidence that if forced by warming they can collapse *very rapidly*, possibly in bursts that would be impossible to precisely predict in advance.
- Some important marine ice sheets:
  - Bentley Trench (central basin in WAIS, good for 3.3 m SLR).
  - Totten Glacier and Denman Glacier, East Antarctica (each good for several metres).
  - Several glaciers in Greenland (e.g., Zacharaie Isstrom, .5 m roughly).

Ice Over Flotation

- Imagine a stack of ice blocks in a bathtub containing about a foot of water.
- The ice is sitting on the bottom of the tub because it is *too heavy to float*.
  - This is *ice over flotation*—there is more ice than can float in a given footprint and depth of water.
- You could keep piling up blocks of ice as long as you want.
  - Key point: if they melt, they will raise the water level.
- Marine ice sheets have huge amounts of ice over flotation.
  - Over millennia, snow builds up and compresses into blue ice within a basin faster than it can flow to the sea.
  - Vast weight of the ice compresses the earth's crust, making the basins deeper.
  - Glacial advances bulldoze out the deep fiords ("overdeepening"), making it easier for sea water to get underneath the ice sheet, and removing obstacles to the ice's flow to the sea.

WAIS: The Restlessly Slumbering Giant

- WAIS (Western Antarctic Ice Sheet) is mostly a grounded marine ice dome:
  - Mountain of ice filling up a large basin (Bentley Trench) that is up to 2500 m below sea level, rising to 1000 m above sea level in central areas.
  - Fronted by Thwaites Glacier, the "Doomsday Glacier".
    - Quick intro: https://en.wikipedia.org/wiki/Thwaites_Glacier
    - Jeff Goodell, "The Doomsday Glacier". Rolling Stone, May 9, 2017. (Excellent introduction.)
- So long as it is cold enough, and the ice sheets are protected from the open sea by ice shelves, these structures can remain stable for tens of thousands of years. *But* —
- There is evidence (partly from paleoclimate, partly from physical analysis) that if relatively warm sea water can get access to the base of such ice domes, they can collapse *catastrophically*, possibly even within a few years (though this remains a matter of investigation).
  - Marine Ice Sheet Instability (MISI): the farther down the retrograde slope the ice front goes, the faster the ice sheet collapses—nasty example of positive feedback!

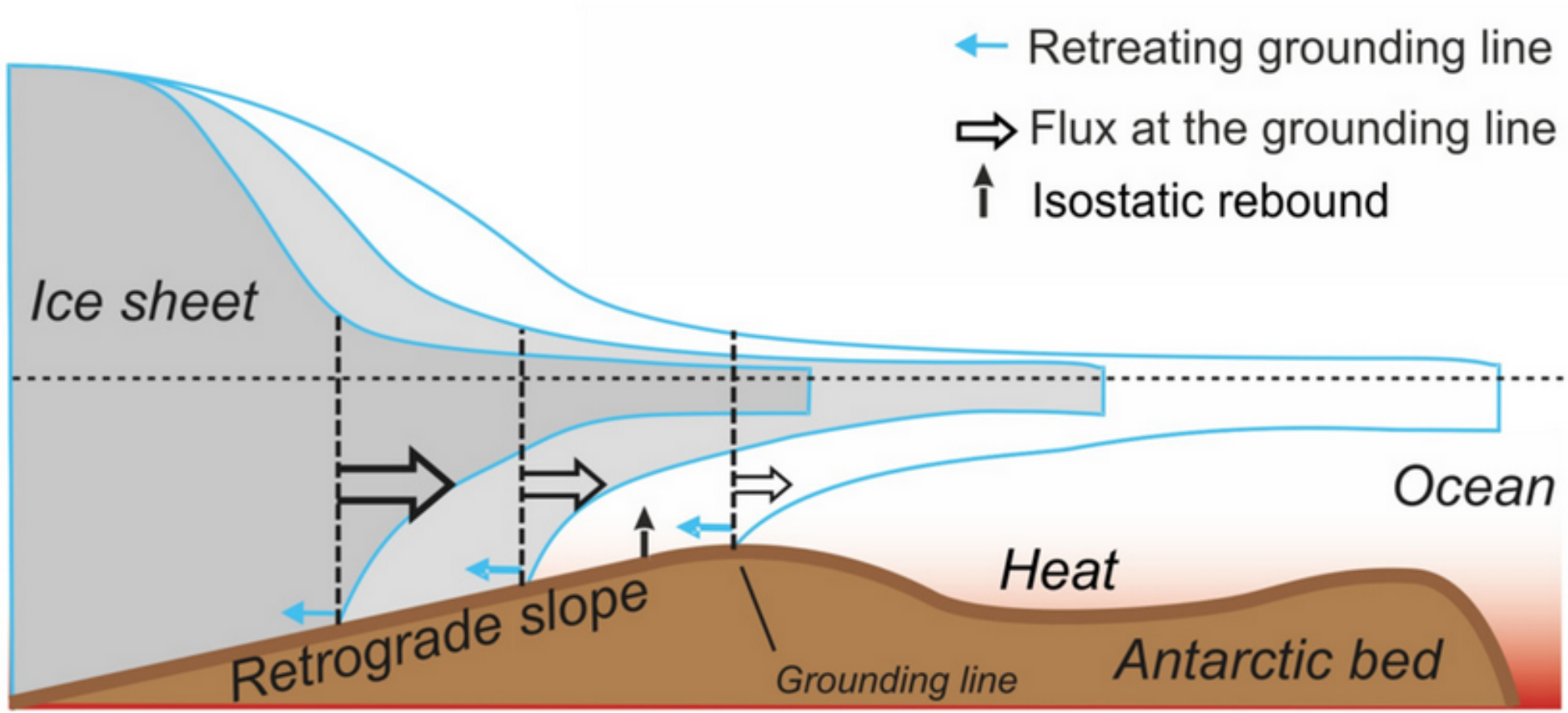


Illustration of Marine Ice Sheet Instability, or MISI. Thinning of the buttressing ice shelf leads to acceleration of the ice sheet flow and thinning of the marine-terminated ice margin. Because bedrock under the ice sheet is sloping towards ice sheet interior, thinning of the ice causes retreat of the grounding line followed by an increase of the seaward ice flux, further thinning of the ice margin, and further retreat of the grounding line. Credit: IPCC SROCC (2019) Fig CB8.1a

See "Marine Ice Sheet Instability 'For Dummies'".

Ice Cliff Instability

- Glacial ice is not very strong structurally as compared to rock—it fails both in tension and shear.
- It is not physically possible for the calving front of a glacier to be more than about 135 m high—the ice is not strong enough.
  - As Richard Alley noted, suppose the calving front advances into the central basin.
  - Because the ice is 1000 m above sea level, the calving face could be 1000 m high.
    - But this is physically impossible—it would come down in the most spectacular calving event since perhaps the last deglaciation…!.
  - Pressure within the ice would accelerate the process (similar to rock bursts in a quarry).
  - The Bentley Trench could conceivably be hollowed out in a matter of months, causing metres of sea level rise all around the world—like a tsunami that does not go away.

Other Bad News

- There are other processes that can accelerate collapse of major ice sheets:
  - Obviously, melt (more important presently in Greenland than Antarctica).
  - Hydrofracturing (surface crevasses fill with water, which wedges ice sheets apart).
  - Crevasses form in the bottom of the Thwaites ice shelf; allowing warm water to eat away at the shelf and fracture it into pieces.
  - Tides cause the shelf to bend up and down, pumping warm water underneath the ice sheet.
  - Fresh melt water releases heat when it mixes with salt water…
  - Isostatic rebound: base of Bentley Trench could spring up like a trampoline, expelling water and ice to the open sea (timeframe uncertain on this one).
- These are the sorts of “nonlinearities” that Hansen mentioned.

Again, How Fast?

- When could this crazy thing (rapid collapse of Thwaites calving front) happen under realistic emission scenarios?
- *We don't know*.
  - However (here's the catch), the chain of events that would trigger such a catastrophe could be set in motion many years before the event itself, and it might be unstoppable beyond a certain point no matter how much we reduce emissions, recycle our beer cans, etc.
    - (That point might possibly be when the grounding line on Thwaites reaches the interior retrograde slope…).
- Hence, our climate policy should be guided not by the principle of brinksmanship ("how close to the edge can we skate?"); but by the Precautionary Principle ("we don't want to go there").
  - (There are interesting parallels between nuclear brinkmanship and climate brinkmanship…).
  - Although current climate policy affects the pretence of sober cost-benefit analysis, it is in fact a form of high-stakes gambling.

Back to the Pliocene

- Lessons from paleoclimate studies:
- Our current CO_2 level (around 420 ppm) is comparable to Pliocene epoch 3 to 3.5 mya:
  - Global mean temperature was 2 – 3 °C higher than today, and sea level was 15 to 25 m higher.
  - If paleoclimate trends are relevant, we have the CO_2 level sufficient to take us back to the Pliocene!
  - But how long will it take for the atmosphere to come to equilibrium?
- Studies of several geological episodes of warming have shown that large amounts of ice can melt very quickly on geological time scale, even with temperature shifts of only a few degrees.
  - E.g.: during melt-down of last glaciation about 11,000 years ago, for a period of about 400 years the sea levels rose *several metres per century*.
  - Sea level is now about 120 metres higher than it was 15,000 years ago.
    - Sea level has varied widely and rapidly in the past, *and there is nothing sacred about our present sea level.*

How Relevant is the Pliocene Precedent?

- "Although ice-sheet, ocean and continental geometries were subtly different during the mid-Pliocene, our results suggest that major loss of Antarctica's marine-based ice sheets, and an associated GMSL [Global Mean Sea Level] rise of up to 23 m, is likely if CO_2 partial pressures remain above 400 ppm."
  - G. R. Grant et al., "The amplitude and origin of sea-level variability during the Pliocene epoch," *Nature* 574, 237-241, 2019.

How Much Could Sea Level Rise *This Century*?

- Even the most conservative estimates by scientists now have sea level rising by at least 1 metre by 2100.
  - Some (e.g., James Hansen) estimate several metres as a worst case scenario.
- Question: should we plan on the basis of well-informed worst case estimates, or most probable/average estimates?
  - Hint for the class: an engineer must design a bridge to be strong enough to withstand the *maximum* load it could experience, not the average!
  - Political agreements (such as Paris 2015) are aimed at the average (66%, one sigma).
- No scientist disagrees that in our present warming regime, sea level will inevitably rise by many metres.
  - Main question: *how quickly can/will this happen?*

“Zombie” Ice

- Very recent game-changing paper:
- Jason Box et al., “Greenland ice sheet climate disequilibrium and committed sea-level rise.” *Nature Climate Change* 12, September 2022, 808-813.
  - Short version: at our *present* temperature levels, we are already committed to 27 (+/ 7) cm of sea level rise from Greenland alone.
  - Box’s opinion is that the *only* thing that could prevent this would be rapid cooling (especially of the Arctic) and/or massive and immediate carbon dioxide drawdown.
  - Box has stated that CO_2 removal must become “the project of the century.”

Jason Box

Is 1.5°C "The Only Option"?

- The Report is ambiguous on what temperature anomaly should be set as the global policy goal.
- They state, "1.5°C is not simply preferable to 2°C or higher, it is the only option."
  - And yet they also state that even at 1.5°C we would eventually be liable to as much as 3 m SLR, and disastrous levels of acidification in the high latitudes that would cripple the oceanic food chain.
  - Possibly this is an instance of what Hansen (2007) called "scientific reticence"—they simply can't bring themselves to spill the bad news.
- The response to this uncertainty is simple: as of this reading (January 2024) we are *already at or over* 1.5°C!
  - We *already know* that 1.5°C is too much!
  - At our *present* climate regime we are *already* committed to damaging SLR and a host of other climatic consequences.
    - As the work of Box et al. shows, it is a *certainty* that we are presently committed to enough sea level rise to force the evacuation of tens of millions of people, loss of sea ports, etc.

Take-Aways

- Long-term climate policy cannot be based on acceptance of a 2°C temperature anomaly (let alone anything higher), since this guarantees sea level rise that would wipe out global civilization as we understand it.
  - Even an anomaly of 1.5C is sufficient to lead to extremely damaging sea level rise (at least 3 m) in the longer run, and lethal levels of acidification.
- IMHO, Long-term policy must be based on holding the temperature anomaly to no more than 1°C.
  - Even at that we can't be sure that we can preserve present coastlines, because of the large amount of excess heat already trapped in the oceans.
- We must take active measures to cool the planet down.
  - How do we do this?
  - Large discussion…

A Suggestion…

- It may be a mistake to use the temperature anomaly as the primary benchmark for climate policy.
  - Feedback is too slow—it could take many years to see whether policy is effective.
  - It is too far away from the base of the causal chain.
  - It ignores effects of carbonization such as oceanic acidification that are not directly temperature-dependent.
- Other possible metrics:
  - CO_2 concentration:
    - Can be easily measured by any country and it is possible to quickly see whether a climate measure is effective.
    - Rapid feedback.
    - Closer to base of causal chain.
  - Or, how about sea level rise?

Why Not Just Admit that We Are Doomed?

- I have to say something about this, since someone is going to ask about it.
- Best statement I have seen about this was made by David Suzuki:
  - "The only thing that gives me hope is that we don't even know enough to say it's too late."
    - Interviewed in Bill Ripple, *The Scientist's Warning* (2022).

What Really Worries Me

- Cynical old saw: “We have the morals we can afford.”
- Writers like Naomi Klein (*This Changes Everything*, 2014) believe that the need to respond to climate change will require humanity to cooperate in a fair and just way.
  - Will we resolve economic inequalities, get beyond the predatory nature of most human interactions?
  - Maybe…
- Problem: As we get closer to stark emergency, it will be harder to respond in a way that is just and equitable.
  - Solutions are more likely to be imposed in a brutal and technocratic way.
  - We might squeak through the climate bottleneck, only to be left with a world that is even more inhumane and unjust than the one we have now.

“Nature’s Best Thermometer…”

- “Nature’s best thermometer, perhaps its most sensitive and unambiguous indicator of climate change, is ice. When ice gets sufficiently warm, it melts. Ice asks no questions, presents no arguments, reads no newspapers, listens to no debates. It is not burdened by ideology and carries no political baggage as it crosses the threshold from solid to liquid. It just melts.”

  — Henry Pollack (*A World Without Ice*, Penguin/Avery, 2009, 114)