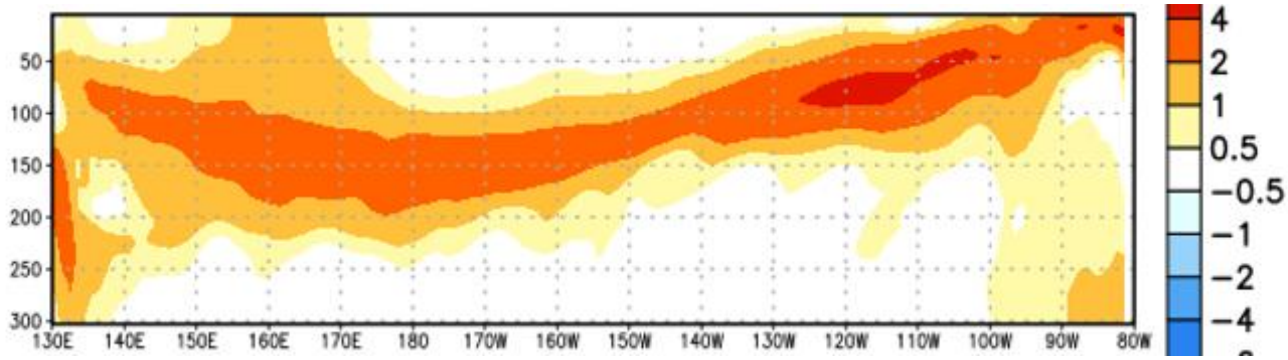

Fig. 1. Temperature anomaly (°C) in equatorial Pacific versus depth (m) and longitude, showing a Kelvin wave that is moving from the western to eastern Pacific (left to right).[1]

Super El Nino? Super Warming is the Main Issue.

20 March 2026

James Hansen, Pushker Kharecha, Dylan Morgan and Jasen Vest

Abstract. Models are converging on prediction of an El Nino beginning this year, peaking in early 2027. After overlooking the possibility of an El Nino this year, some reporting is jumping on a "Super El Nino" bandwagon. El Nino strength and frequency are important, especially the issue of whether these are modified by global warming. However, the more important knowledge that needs to be extracted from near-term global warming concerns interpretation of ongoing, extraordinary, acceleration of ocean surface warming. Impacts of this ocean warming include a factor of two greater warming over land, increased extreme precipitation, and poleward movement of subtropical conditions.

The fundamental advance in the past five years in understanding of global climate change is realization that equilibrium climate sensitivity is substantially larger than the long-standing best estimate of 3°C for doubled CO_2. The underestimate was due to an implicit assumption that aerosol climate forcing changed negligibly during the period of rapid linear warming that began about 1970 and on heavy dependence of climate sensitivity assessments on observed warming of the past century. Multiple data sources now indicate that climate sensitivity is 4-5°C, which is consistent with aerosol-cloud modeling that reveals increasing aerosol cooling during the 1970-2005 period of rapid linear warming because of increased global spread of the aerosol sources. This explains why underlying climate sensitivity must be larger to account for the observed temperature rise. High climate sensitivity and reduction of East Asia and ship aerosol sources in the past 10-15 years combine to drive accelerated sea surface temperature warming. The first author appeals to his longtime friend Bill McKibben to help communicate the current knowledge because of the implications for the wellbeing of today's young people and their children.

We are developing a website that will be continually updated with the aim of aiding understanding of long-term climate change. We also are now on Substack[2]

An El Nino is anticipated to begin later this year and peak in 2027. The ECMWF (European Center for Medium-Range Weather Forecasts) model, one of the best models, predicts a strong "Super" El Nino. It is useful to know how strong the El Nino will be because of important effects that El Ninos have on global weather patterns. Let us first clarify how El Ninos work.

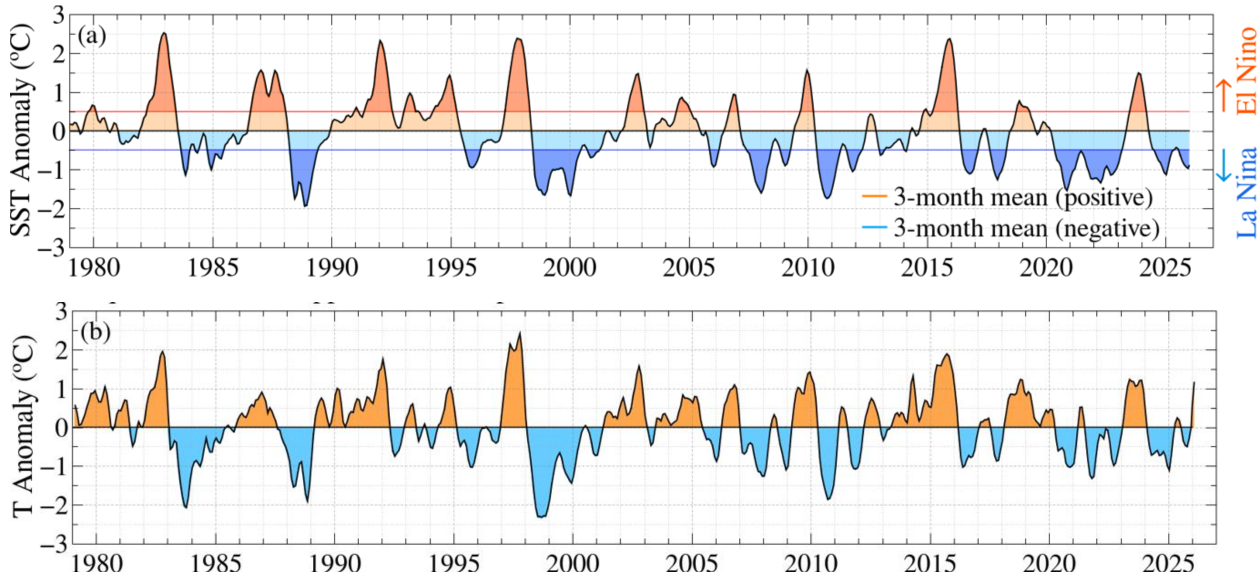

Fig. 2. (a) Nino3.4 SST,[3] (b) equatorial upper ocean (300 m) heat anomaly (°C) 180-100W: both are 3-month running-means except February 2026, which is a 1-month value in (b).

El Nino – La Nina cycle. La Nina is the more common phenomenon and can be characterized as the normal state of the tropical Pacific because it is the response to the prevailing easterly (east-to-west) winds in the tropics (the tropical "trade winds," which are complemented by prevailing mid-latitude westerly winds). The equatorial winds normally push warm surface water toward the west, thus causing upwelling of cold deepwater along the coast of South America. The deepwater is nutrient rich, in part because fish poop and dead organisms tend to sink, accumulating biologic material at depth. Thus, the coastal waters west of South America are usually highly productive, with anchovies, other fish, birds, animals – until an El Nino occurs.

An El Nino can be triggered by a series of tropical wind bursts from the west that weaken or even reverse the trade winds. The warm surface water, which is normally piled up in the west [with sea level half a meter (about 20 inches) higher near Indonesia than near South America], thus sloshes back toward South America, where the warming of surface water prevents the colder, denser, deepwater from upwelling. The coastal biologic productivity declines, anchovies disappear and birds die. The main route of heat from the west to the east is a large Kelvin (thermal) wave, or series of waves, of heat in the upper few hundred meters of the ocean; the present wave is shown in Fig. 1. Kelvin waves serve as a conveyor transporting heat from the west toward the east, where it is released to the atmosphere and enhances global warming.

El Nino indicators. Nino3.4 (Fig. 2a), the SST (sea surface temperature) anomaly in the equatorial Pacific between longitudes 170-120W, is the usual measure of El Nino-La Nina status. The temperature anomaly in the upper 300 m (Fig. 2b) of nearly the same region of the ocean has the advantage of providing a measure of the heat anomaly on the conveyor and it provides a much longer lead time in predictability of Nino-driven global temperature anomalies, as shown in our recent post.[4] Moreover, the 300 m heat provides the mechanism for El Nino to warm the global atmosphere. The Kelvin wave carries heat from the west to the east, where it surfaces, warming the ocean surface in the eastern tropical Pacific. Heat is transferred to the atmosphere via increased evaporation from the ocean surface, the water vapor then condensing in the atmosphere, releasing the latent energy. The heat is energy that accumulated in the West Pacific

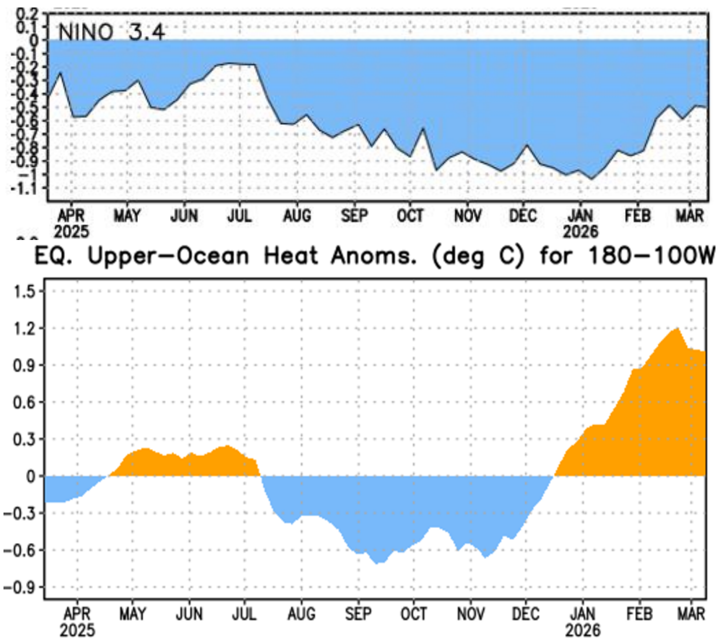

Fig. 3. Nino3.4 and 300m heat anomaly in the past year from NOAA's weekly update.[1]

during La Nina, which is why it would be a bit surprising to have a Super El Nino so soon after the moderately strong 2023-24 El Nino. It takes time to recharge the "battery" of heat in the East Pacific, but perhaps human-made warming is decreasing the time needed to recharge the battery.

Let's see if the 300 m heat anomaly already foreshadows an upcoming El Nino and whether it will be a Super El Nino. Fig. 3 shows Nino3.4 SST (a) and 300 m heat anomaly (b). Nino3.4 is still in negative (La Nina) territory, but the 300 m temperature implies that change is on the way. Weekly data (Fig. 3) have the 300 m heat topping out at only +1°C, which would be too weak to drive a Super El Nino, but that could be a temporary feint, as discussed below.

Let's compare the present situation with the three most recent Super El Ninos (Fig. 4a) and the three most recent modest El Ninos (Fig. 4b). The heat content for the present case started early and is rising rapidly like the Super El Ninos (Fig. 4a), unlike the moderate El Ninos (Fig. 4b). The 1982-83 Super El Nino seems to be an oddball.[5] For the present situation to develop into a Super El Nino, the decline of 300 m heat during the past few weeks (Fig. 3b) needs to be reversed. Such reversal is possible, as El Ninos are often built by a series of Kelvin waves rather than a single pulse.

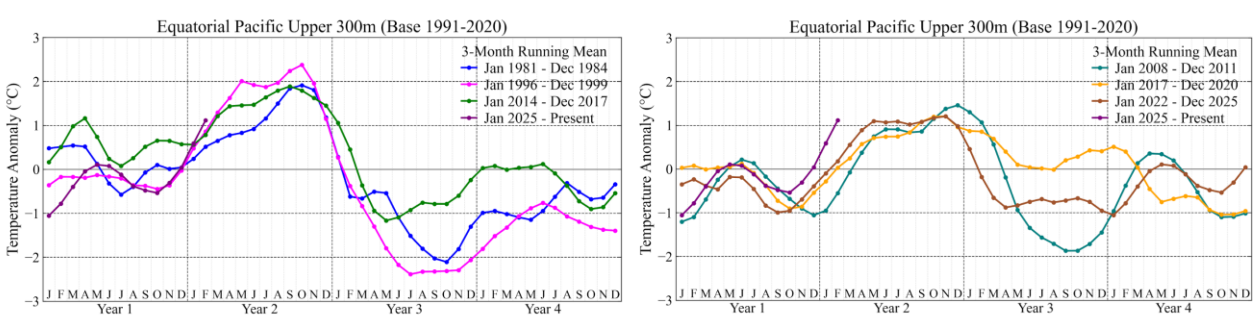

Fig. 4. Ongoing 300 m heat compared to (a) Super El Ninos, and (b) moderate El Ninos.

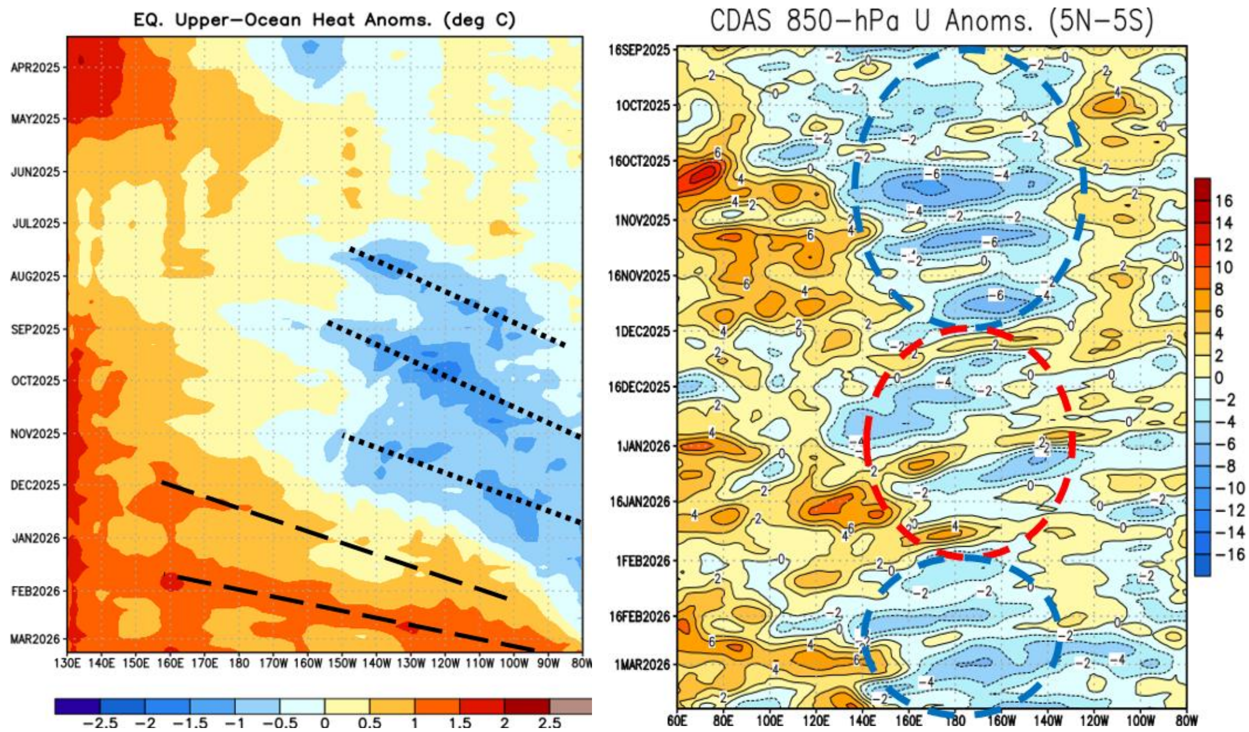

Fig. 5. Upper ocean (300 m) ocean heat versus time (vertical axis) and longitude. Time runs from April 2025 at the top to March 2026 at the bottom. The similar diagram on the right shows equatorial wind anomalies; yellow-red is increased westerlies, blues are easterlies.[1]

Kelvin waves frequently occur in series, as shown in Fig. 5, which covers the past 12 months. The present Kelvin wave, marked by the long dashes at the bottom of the diagram, traveled across the Pacific over the past two months from early January to early March, when it surfaced near the South American coast (right side in Fig. 5) and changed the ocean surface temperature anomaly from negative (light blue) to positive. This positive (red) Kelvin wave pushes warm water from the west toward South America, depressing (deepening) the thermocline (the boundary between warm surface water and deep cold water); as it nears South America, it can prevent the normal upwelling of cold deepwater along the coast. The present Kelvin wave was preceded by a weaker positive Kelvin wave (Fig. 5, left) that only reduced the magnitude of the La Nina cooling near the coast. There is a hint (Fig. 5, left) that another positive Kelvin wave may be coming – we should learn soon, as time gradually exposes more of the diagram.

We will update the figures in this article (available on our website) each week as the El Nino develops, but the NOAA figures are always available on their website,[1] which is normally updated every Monday.

Whether a Super El Nino develops depends in part on the strength of the potentially upcoming Kelvin wave, and that depends in turn on the fickle equatorial winds, as shown by the wind anomalies in the right side graph of Fig. 5. Stronger than average westerly wind bursts (yellow-red colors) would push more warm water eastward (i.e., toward South America), depress the thermocline further, and strengthen the El Nino. Other factors besides these quite-chaotic winds influence the outcome, which makes modeling of El Ninos notoriously difficult. It would be helpful if the ECMWF or other modeling experts, after this event is finished, would write an account in plain language for public benefit, including an interpretation of knowledge gained.

Progress in understanding climate change has been significant in the past five years. As we have discussed elsewhere,[6,7] the most important result is that climate sensitivity is significantly higher than the long-standing estimate of 3°C for doubled carbon dioxide, a conclusion we can state with greater than 99 percent certainty. Jessica Tierney showed that the last major ice age (20,000 years ago) was about 6°C colder than the present interglacial period,[8] rather than about 4°C, as long assumed. Tierney could improve on prior analyses because enough ice age data were available to allow exclusion of data based on a dubious assumption about ocean biology.[9] Matt Osman, similarly, showed that the peak of the ice age was about 7°C colder.[10]

Alan Seltzer provided the clinching data: noble gas amounts in groundwater deposited during the ice age were 6°C colder for the latitude range 45°S-35°N.[11] This result for limited land area must be adjusted to account for temperature change of ocean being less than on land and the fact that temperature change at high latitudes exceeds that at low latitudes; these two adjustments almost exactly offset each other.[6] Also, we must adjust for the large ice sheets that existed in the ice age at high latitudes; the additional cooling from ice sheets increased global cooling to about 7°C, consistent with the Tierney and Osman results.

This comparison of two equilibrium climate states, the last ice age and the present interglacial period, provides the best measure of climate sensitivity: 4-5°C for doubled carbon dioxide.[6] There are three additional independent assessments of climate sensitivity, which support this estimate. We number these 2-4 and order them from the most to the least quantitatively helpful.

The 2nd source of information is the large reduction of Earth's albedo (reflectivity) in the period of precise satellite data that began in year 2000. The albedo reduction is so large that most of it must be due to a reduction of sunlight reflected by clouds, as the contributions from reduced sea ice cover and reduced human-made atmospheric aerosols are relatively small.[7] This implies that clouds are a strong, amplifying, climate feedback. If clouds were neutral (no net warming or cooling effect)*,* climate sensitivity would be about 2.4°C for doubled carbon dioxide because water vapor and sea ice feedbacks roughly double the no-feedback climate sensitivity of 1.2°C. The large cloud feedback implies a climate sensitivity of at least 4°C. These albedo observations will provide a more precise evaluation of climate sensitivity as the record becomes longer.

The 3rd source of information is knowledge of when the Earth was last a snowball.[12,13] The Sun is an ordinary star of modest mass, "burning" hydrogen in nuclear fusion, slowly becoming brighter at a rate of 1 percent per 100 million years. The last "snowball Earth," when ice reached sea level at the equator, was about 600 million years ago. A 2 percent change of solar irradiance is a climate forcing equivalent to that for doubled carbon dioxide. Thus, the 6 percent change of the Sun's brightness since the last snowball is equivalent to three doublings of carbon dioxide. The fact that only a 6 percent solar irradiance change is needed to cause snowball Earth implies that climate sensitivity is high, about 4-5°C for doubled carbon dioxide, and Earth system sensitivity (including ice sheet changes neglected in Charney's sensitivity) is even higher.[14]

The 4th source of information on climate sensitivity is observed global warming over the past 1-2 centuries, which is the focus in IPCC reports. This is least accurate of the four sources because it requires knowledge of the net climate forcing that drove the global warming. There are two large climate forcings in that period: human-made greenhouse gases and human-made aerosols, but the aerosol forcing was not measured. Most global warming occurred post-1970 at a steep rate of almost 0.2°C per decade. During that period of rapid warming, IPCC's best estimate of aerosol forcing is essentially unchanging; in that case, climate sensitivity near 3°C for doubled carbon dioxide provides the best match to observed warming.

The IPCC aerosol forcing would be reasonable, if global aerosol forcing was simply proportional to global sulfur dioxide emissions, the precursor to dominant sulfate aerosols. However, forcing from aerosols occurs mainly via their effect on cloud formation: aerosols are condensation nuclei for cloud drops, so more aerosols yield more, brighter, clouds. This aerosol effect saturates: once there are enough aerosols, adding more has less effect. During the period from 1970 to early in the 21st century, global sulfur dioxide emissions changed little, but they were more dispersed, as reduced emissions in the United States and Europe coincided with increases in East Asia. Also, emissions spread more over the ocean. Modeling of the aerosol effect on clouds suggests that aerosol cooling increased in that period, with a negative climate forcing that offset about a third of the greenhouse gas forcing. In that case, the best fit to observed global warming requires a climate sensitivity of about 4.5°C for doubled carbon dioxide. Still greater aerosol cooling, with climate sensitivity of 6°C is also conceivable. However, among the three cases, 3, 4.5 and 6°C, the 4.5°C sensitivity provides the best fit to observed warming over the 1850-present period.[7]

Evidence for high climate sensitivity is now clear. Climate sensitivity as low as 3°C is ruled out with greater than 99 percent confidence. Aerosol cooling was underestimated by IPCC, which means there is additional warming in the pipeline as the world moves to cleaner fuels. These two factors – high climate sensitivity and warming from reduced aerosol amount – are independent matters that together significantly change the climate story.

Summary. Climate science pundits who previously overlooked the possibility of an El Nino this year now seem to be jumping on a Super El Nino bandwagon. El Nino strength and frequency are important, especially the issue of whether these are being modified by global warming. However, a more important topic is the ongoing, extraordinary, acceleration of ocean surface warming. Our task as scientists is to extract as much knowledge as possible from near-term global change to aid policy decisions in coming years. The very nature of climate change, with its delayed response to imposed climate forcings, demands that we do everything we can to help young people understand the situation they are inheriting and actions they can take to achieve a bright future. With that objective in mind, and giving it priority over social niceties, the first author includes a note to his long-time friend, Bill McKibben.

Bill,

I am shocked and dismayed at your characterization of my criticisms as "trash talk;" I refer to my criticisms of the clique of climate scientists who eagerly serve as "go to" experts for the media, as discussed below. Further, you say that I am "brash," leaving the impression that the clique is composed of wiser, more thoughtful, experts.

Science reporting. Bill, you have orders of magnitude more followers than I do, for good reason. Your humanity shines through in your prolific writings, your reach expanded globally with your landmark 1989 book, "End of Nature," and you write in a way the public understands and appreciates. Because of that, you now serve as more than a moral compass, but also as a science reporter, given the limitations of good science reporting in the media (budgets trimmed to a fraction) and limitations of we scientists as communicators. You report frequently on the state of climate science. When you include an evaluation of the science, people listen.

We addressed the physics of the problem, as summarized above in discussing the four principal sources of information. None of these matters were addressed by the clique of climate "experts" who spoke in the media the day after our paper "Global warming has accelerated"[7] came out. Instead of addressing the climate physics, the criticisms were ad hominem" "Hansen exaggerates," "Hansen makes lots of mistakes," "Hansen is not collegial," our analysis was "too simple" and our conclusions were "outside the mainstream." These experts thus totally shut down public discussion of our paper. Steve Kolmes, the editor of Environment, was stunned; you should speak with him, if you think that I am exaggerating. The media has "go to" scientists who are willing or eager to speak out. I was reminded of this when Seth Borenstein of the Associated Press told me that he could not write about our paper "Ice Melt, Sea Level Rise, and Superstorms" because 5 of his 6 "go to" scientists advised against it. That's a story for another time.[15]

This is not rocket science. You can understand it and help explain it to people. Aerosol forcing was still increasing (causing more cooling) during the period 1970-2005, as aerosols were spread more globally, reducing the net forcing from about 0.45 to 0.3 W/m^2 per decade (GHG minus aerosol forcings). Recently, at least since ~2015, the aerosol change (reduced aerosol amount, thus reduced cooling) adds to the GHG forcing instead of subtracting from it, thus producing a net forcing near 0.6 W/m^2 per decade. No wonder global warming is accelerating.

Why do they resist this? Why argue that the real world is still somewhere within the model fog? The climate model sensitivity is set by choices of scores of quantities over decades of model development. Choice among alternative model versions, i.e., choice of model parameters, is influenced by which model gives better agreement with global warming. If the model was developed with aerosols close to IPCC's best estimate (negligible change of aerosol forcing during 1970-2005), the model needs to have a sensitivity near 3°C for doubled CO_2 to match observed warming. So, if the aerosol forcing was not actually constant, that's a BFD. It is not so easy to go back and make different parameter choices. It's a lot easier to say the real world is still in the model fog, or Hansen is full of it. Let's just ignore the four ways that they showed climate sensitivity is high.

Why does this matter? Climate sensitivity and aerosols are two independent matters, tied together only because of the way the modelers make their choices. That's a reason for having independent ways to determine climate sensitivity, i.e., the list of four ways that the modelers do not want to talk about. It matters because the switch from 0.3 to 0.6 W/m^2 per decade is the reason that Earth's energy imbalance doubled and global SSTs increases are accelerating.

But the real reason this matters is that we need to inform young people accurately about the situation to help them deal with it. This funny business with the clique was enough to get me off the farm to live in an apartment, where I can work much more efficiently.

Best, Jim

[1] The NOAA Climate Prediction Center updates El Nino information every week, normally on Monday. Figures 1, 3 and 5 here were copied from their post on 16 March 2026.
[2] https://jimehansen.substack.com/

[3] The Nino3.4 SST curve reflects NOAA's Relative Oceanic Nino Index, an adjustment to remove a long-term trend, as described in reference 1

[4] Hansen J, Kharecha P, Morgan D, Vest J. Another El Nino Already? What Can We Learn from It? 06 February 2026

[5] M Hirono (On the trigger of El Nino southern oscillation by the forcing of early El Chichon volcanic aerosols, *J Geophys Res* **93(D5)**, 5365-84, 1988) argues that aerosols injected in the northern subtropics in 1982 (year 2 of Fig. 4) by the El Chichon volcanic eruption induced westerly winds. This might have amplified an ongoing moderate El Nino causing the late rise in the 300 m heat content, although A Robock (Volcanic eruptions and climate, *Rev Geophys* **38 (2)**, 191-219, 2000) is skeptical of the volcanic effect on El Ninos.

[6] Hansen JE, Sato M, Simons L *et al*. "Global warming in the pipeline," *Oxford Open Clim. Chan.* 3 (1) (2023): doi.org/10.1093/oxfclm/kgad008

[7] Hansen JE, Kharecha P, Sato M *et al.* Global warming has accelerated: are the United Nations and the public well-informed? *Environ.: Sci. Pol. Sustain. Devel.* **67**, 6–44, 2025, https://doi.org/10.1080/00139157.2025.2434494

[8] Tierney JE, Zhu J, King J *et al.* Glacial cooling and climate sensitivity revisited. *Nature* **584**, 569-73, 2020

[9] Tierney was able to exclude from her analysis the assumption that microbiota in the ocean do not adapt to temperature change, even over millennia. With that prior, dubious, assumption, ice age ocean temperatures were set based on the temperatures that a given species tolerates today.

[10] Osman MB, Tierney JE, Zhu J *et al.* Globally resolved surface temperatures since the Last Glacial Maximum. *Nature* **599**, 239-44, 2021

[11] Seltzer AM, Ng J, Aeschbach W *et al.* Widespread six degrees Celsius cooling on land during the Last Glacial Maximum. *Nature* **593**, 228-32, 2021

[12] Hoffman PF, Schrag DP. The snowball Earth hypothesis: testing the limits of global change. *Terra Nova* **14,** 129-55, 2002

[13] Oscillations between snowball Earth and a nearly ice-free planet occurred several times prior to 600 million years ago, when the Sun was less bright. When Earth is ice and snow covered, weathering nearly stops. Weathering carries carbon and other chemicals to the ocean, resulting in the formation of limestone on the ocean's floor, thus removing carbon dioxide from the air. Without weathering, carbon dioxide emitted by volcanoes builds up in the atmosphere until the greenhouse effect is strong enough for ice to melt at low latitudes. Once melting begins, the amplifying snow/ice albedo feedback drives global deglaciation. Weathering then begins to reduce atmospheric carbon dioxide.

[14] Hansen J, Sato M, Russell G *et al.* Climate sensitivity, sea level, and atmospheric carbon dioxide. *Phil Trans R Soc A* **371**, 20120294, 2013

[15] Hansen J, Sato M, Hearty P *et al*., "Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observations that 2C global warming is highly dangerous," *Atmos Chem Phys* **16** 3761-812, 2016. Based on global climate modeling, paleoclimate analyses, and ongoing observations of climate processes, we inferred that the threats of long-term climate change were more imminent than IPCC recognized. Using a model that did a good job of simulating deepwater formation, we concluded that continued increasing greenhouse gas emissions is likely to cause shutdown of the ocean's overturning circulations (AMOC and SMOC) by midcentury. Those shutdowns, in turn affect melting of Antarctic ice shelves, and would likely cause multimeter sea level rise on the century (not millennial) time-scale. The Southern Meridional Overturning Circulation is fed by Antarctic Bottom Water Formation at several coastal sites around Antarctica. This deepwater tends to fill the lower half of the global ocean, but its volume has been shrinking over the past several decades as meltwater reduces the rate of bottom water formation. This ocean circulation is an important player in the global carbon cycle.