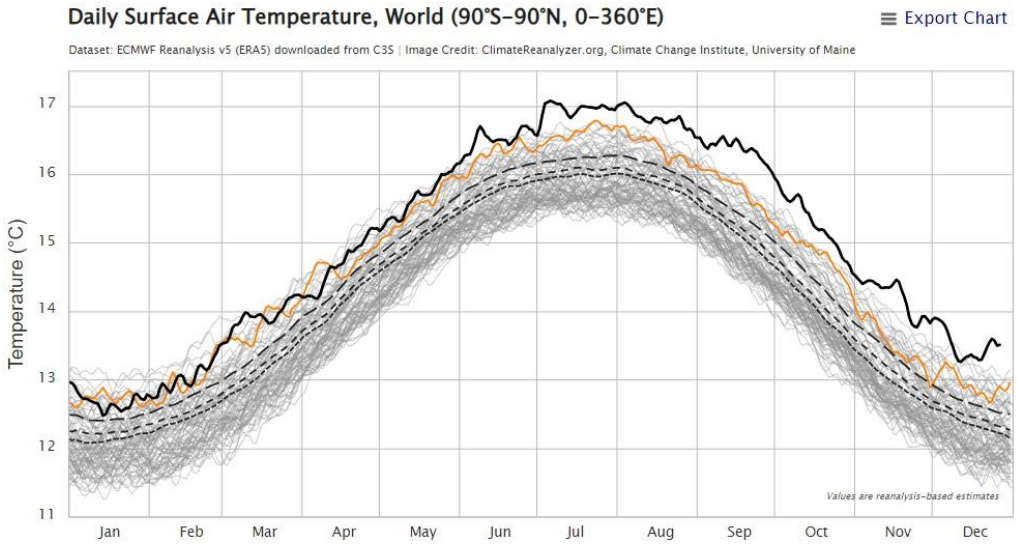

Fig. 1. Daily surface temperature analysis from the ECMWF reanalysis version 5 (ERA5).[1]

Groundhog Day. Another Gobsmackingly Bananas Month. What's Up?

04 January 2024

James Hansen, Makiko Sato, Pushker Kharecha

Abstract. December was the 7th consecutive month of record-shattering global temperature, driven by the combination of a moderately strong El Nino and a large decrease of Earth's albedo. The El Nino will fade in the next few months, but we anticipate that the string of record monthly temperatures will continue to a total of 12 and possibly 13 months because of Earth's unprecedented energy imbalance. By May the 12-month running-mean global temperature relative to 1880-1920 should be +1.6-1.7°C and not fall below +1.4 ± 0.1°C during the next La Nina minimum. Thus, given the planetary energy imbalance, it will be clear that the 1.5°C ceiling has been passed for all practical purposes.

Zeke Hausfather memorably termed the record September global temperature as "gobsmackingly bananas." Subsequent monthly temperature anomalies have not been much smaller. These records coincide with a moderately strong El Nino, but they exceed expectations for even the strongest El Nino, if that were the only driving factor. Warming is also being driven by another factor, one that

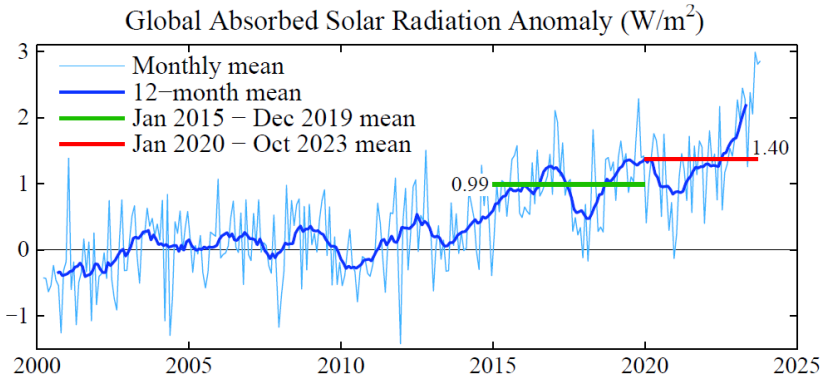

Fig. 2. Global absorbed solar radiation (W/m²) relative to mean of the first 120 months of CERES data. CERES data[2] are available at http://ceres.larc.nasa.gov/

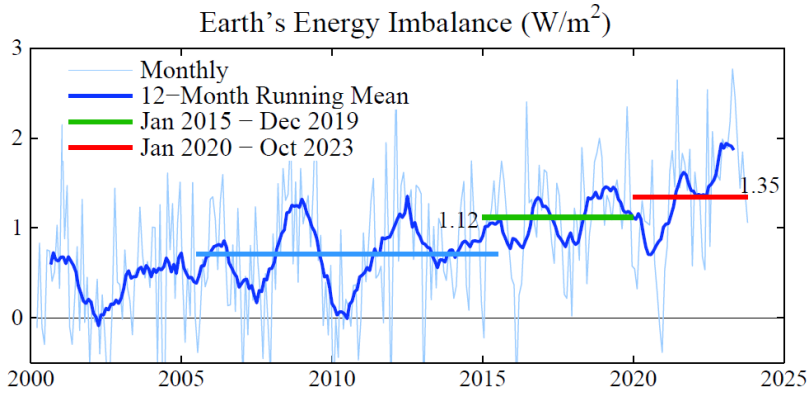

Fig. 3. 12-month running-mean of Earth's energy imbalance from CERES satellite data normalized to 0.71 W/m^2 mean for July 2005 – June 2015 (blue bar) from in situ data.

is ultimately more consequential: a large decrease of Earth's albedo. In other words, Earth has become darker, absorbing more of the sunlight incident on the planet (Fig. 2). The increase of absorbed solar radiation (1.4 W/m^2) is a decrease of Earth's albedo (reflectivity) of 0.4% (1.4/340).[3] This reduced albedo is equivalent to a sudden increase of atmospheric CO_2 from 420 to 530 ppm.

We conclude in our *Pipeline* paper[4] that the decreased albedo is spurred by reduced atmospheric aerosols and enhanced by feedbacks. Given that NASA decided in the early 1990s[5] not to make precise measurements of the global aerosol forcing and cloud feedbacks, we are faced with a difficult task of sorting out how much of the increased solar absorption is aerosol forcing and how much is from feedbacks. The two major feedbacks expected to darken Earth as the planet warms are reduced sea ice cover and reduced cloud cover. The recent spike of absorbed solar radiation to almost 3 W/m^2 (Fig. 2) may be related in part to the fact that it occurred during the season when solar insolation was rising in the region of Southern Hemisphere sea ice when sea ice cover was at its lowest point in the period of satellite data. Large variability of clouds, unforced and forced, complicates interpretation of anomalies, but spatial variations may help untangle the situation.

Feedbacks associated with ice melt are particularly important for reasons discussed in our *Ice Melt* paper[6] (that's the paper blackballed by IPCC because it disagrees with IPCC about the imminent threat of shutdown of the overturning ocean circulations and large sea level rise). We find in that paper that freshwater injection into the ocean mixed layer by melting polar ice is already a significant climate forcing that acts to slow down the production of deepwater in the North Atlantic and production of bottom water in the Southern Ocean.

Moreover, this freshwater injection drives a crucial climate feedback that any lay person can understand. The freshwater injection – in the form of glacial meltwater and icebergs – cools the ocean surface creating a heat sink, as a large amount of energy is needed to melt the ice. This heat sink and cool ocean surface increase Earth's energy imbalance. As shown in *Ice Melt*, this increase of Earth's energy imbalance provides energy to melt ice faster.

It is possible to shut off this amplifying feedback by cooling the planet, but that can happen only if we reduce the present enormous geoengineering of the planet. This will require purposeful actions to cool the planet, in addition to phasing down greenhouse gas emissions as rapidly as practical. Fortunately, there are young people who are beginning to grasp the situation that they are being handed by older generations. We will write a paper in cooperation with enlightened young people

from Finland,[7] Eric Rignot, and several other people discussing this situation. We intend to complete the paper this coming spring, by which time we expect to have additional data that test our interpretation of ongoing global change.

Figure 4 includes our expectation that continuing record monthly temperatures will carry the 12-month temperature anomaly to +1.6-1.7°C. During subsequent La Ninas, global temperature may fall back below 1.5°C to about 1.4±0.1°C, but the El Nino/La Nina mean will have reached 1.5°C, thus revealing that the 1.5°C global warming ceiling has been passed for all practical purposes because the large planetary energy imbalance assures that global temperature is heading still higher.

We are grateful to the people who responded to our appeal for support[8] of Climate Science, Awareness and Solutions, thus helping assure an additional perspective in the discussion of actions needed to address ongoing global climate change.

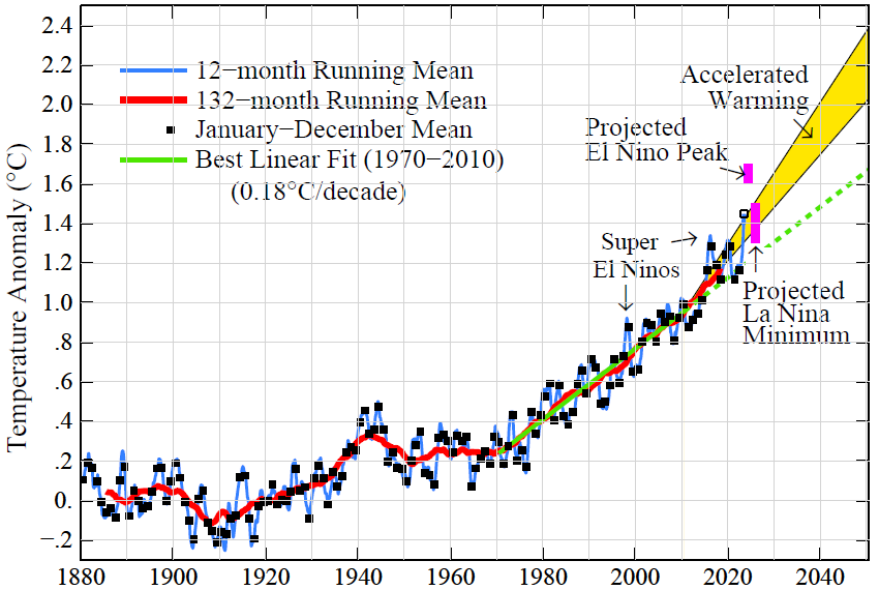

Fig. 4. Global temperature relative to 1880-1920 based on the GISS analysis[9,10] through November and an estimate of the December anomaly using data of Fig. 1.

---

[1] Daily Surface Air Temperature graph based on ERA5 available via Climate Reanalyzer, Climate Change Institute, University of Maine https://climatereanalyzer.org/wx/todays-weather/?var_id=t2&ortho=1&wt=1

[2] Loeb NG, Johnson GC, Thorsen, TJ *et al.* Satellite and ocean data reveal marked increase in Earth's heating rate. *Geophys Res Lett* 2021;**48**:e2021GL09304

[3] The average solar energy incident on Earth is about 340 W/m^2.

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

[5] Hansen J, Rossow W, Fung I. *Long-term monitoring of global climate forcings and feedbacks*. Washington: NASA Conference Publication 3234, 1993

[6] 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 2 C global warming could be dangerous. *Atmos Chem Phys* 2016;**16**:3761-812

[7] Operaatio Arktis. Sep 6, 2023. 1.5°C Gone Without Climate Intervention – So What's the Plan? – Anni Pokela, Operaatio Arktis [Video]. YouTube: https://www.youtube.com/watch?v=0It_xZnLdyo

[8] Hansen J, Kharecha P, Sato M. "A Miracle Will Occur" Is Not Sensible Climate Policy, 7 December 2023

[9] Lenssen NJL, Schmidt GA, Hansen JE *et al.* Improvements in the GISTEMP uncertainty model, *J Geophys Res Atmos* 2019;**124(12)**:6307-26

[10] Hansen J, Ruedy R, Sato M *et al.* Global surface temperature change. *Rev Geophys* 2010;**48**:RG4004