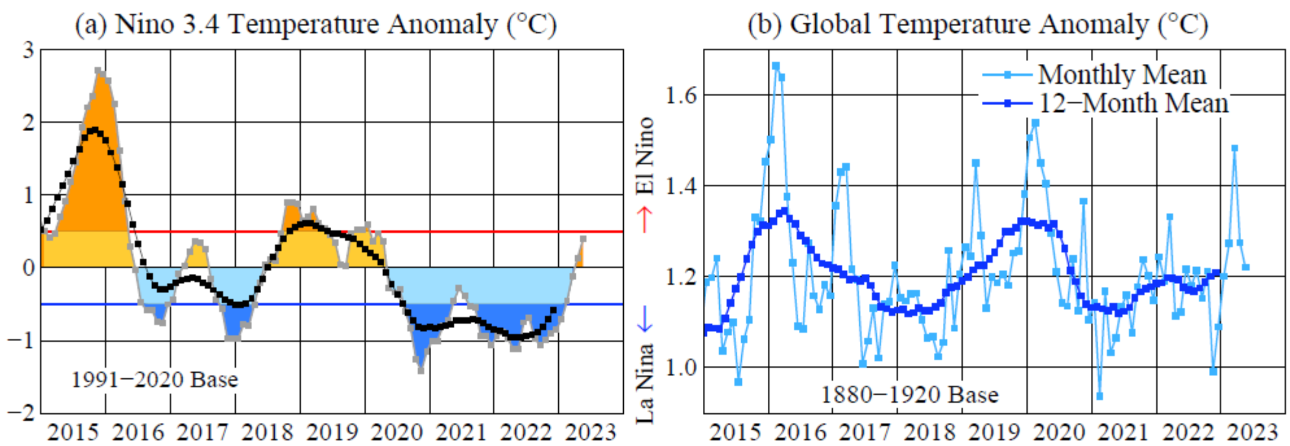

Fig. 1. (a) Nino3.4 and (b) global temperatures relative to indicated base periods.

El Nino and Global Warming Acceleration

14 June 2023

James Hansen, Makiko Sato and Reto Ruedy

The birthing El Nino will be a measuring stick. Is the rate of global warming accelerating? The little futz of an El Nino in 2019 (Fig. 1a) barely qualified[1] as an El Nino, yet it produced (dark blue curve in Fig. 1b) a global temperature matching that of the 2016 super El Nino. Jeremy Grantham noted that the 2016 El Nino produced greater warming than the prior super El Nino (in 1997); he was concerned that it indicated an acceleration of global warming.[2] We have argued[3] that the principal mechanism that may cause acceleration of global warming is a decrease of human-caused aerosols (particulate air pollution), which reflect sunlight and thus have a cooling effect that partially offsets warming by greenhouse gases (GHGs). That cooling has been termed a Faustian bargain,[4] and we have suggested that a significant payment in accelerated global warming is now coming due.[3,5]

Short-term global temperature change is correlated (59%) with the Nino3.4 temperature index[6] (Fig. 2). The Pinatubo volcanic eruption in 1991, and to a lesser extent solar irradiance variation, reduce the correlation. The greatest anomaly in global warming occurs since 2015 (Fig. 2), which we attribute to reduced aerosol cooling, including the effect of increasingly strict limits on the sulfur content of ship fuel imposed by the International Maritime Organization in 2015 and 2020.[3]

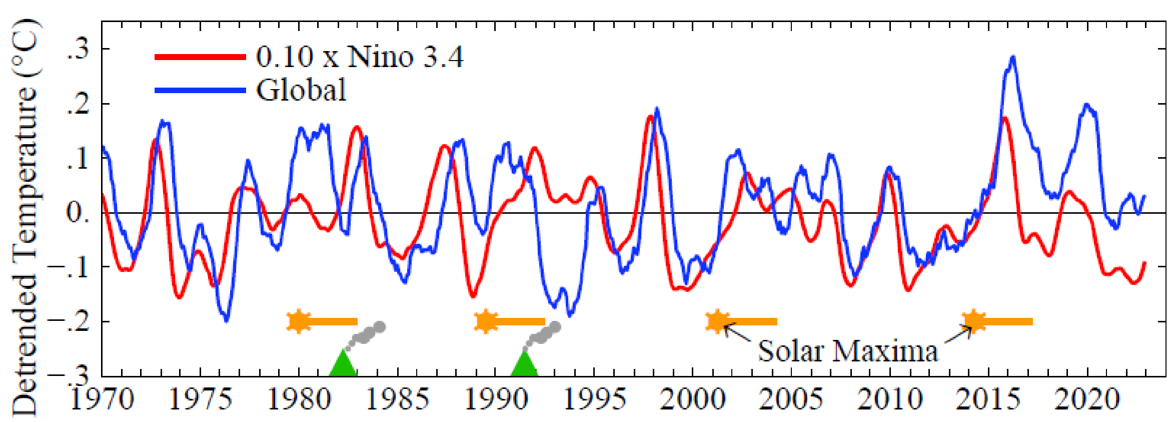

Fig. 2. Detrended global and Nino3.4 12-month running-mean temperatures; the trend subtracted from the temperature records is based on the period 1970-2010.

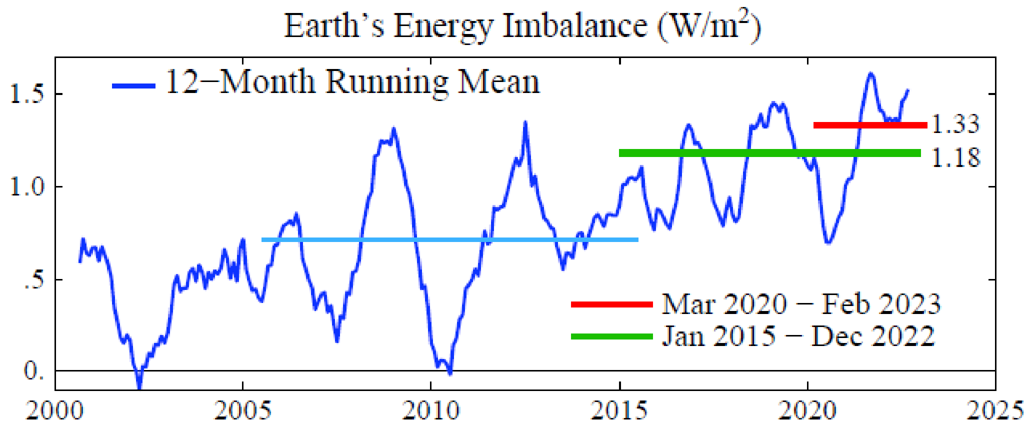

Fig. 3. 12-month running-mean of Earth's energy imbalance, based on CERES satellite data[7] for EEI change normalized to 0.71 W/m^2 mean for July 2005 – June 2015 from in situ data.

Consistent with this interpretation, there has been a staggering increase in Earth's energy imbalance (Fig. 3). The light blue bar in Fig. 3, the 10 years from July 2005 through June 2015, is the period used for calibration of the satellite-measured[7] Earth's energy imbalance (EEI), the calibration being provided by changes of the heat content of Earth's heat reservoirs.[8] About 90% of the change of EEI is change of the heat content of the ocean, which is sampled by a fleet of about 4000 deep-diving Argo floats. Earth's energy imbalance was 0.71 W/m^2 during the 10-year calibration period, but EEI has subsequently increased to well over 1 W/m^2 (Fig. 3). EEI provides the direct driving force for global warming and all of the consequences thereof.[3] It is this increased EEI that leads us to project a 50-100% increase in the rate of global warming during the few decades following 2010. If our projection is correct, we expect observed global temperature to rise into the yellow region in Fig. 4 in 2023 and above the yellow region in 2024. This is a projection that we hope is wrong, but the main factors that might cause it to be wrong are not very comforting: the El Nino strength affects short time scales and aerosol trends affect long time scales.

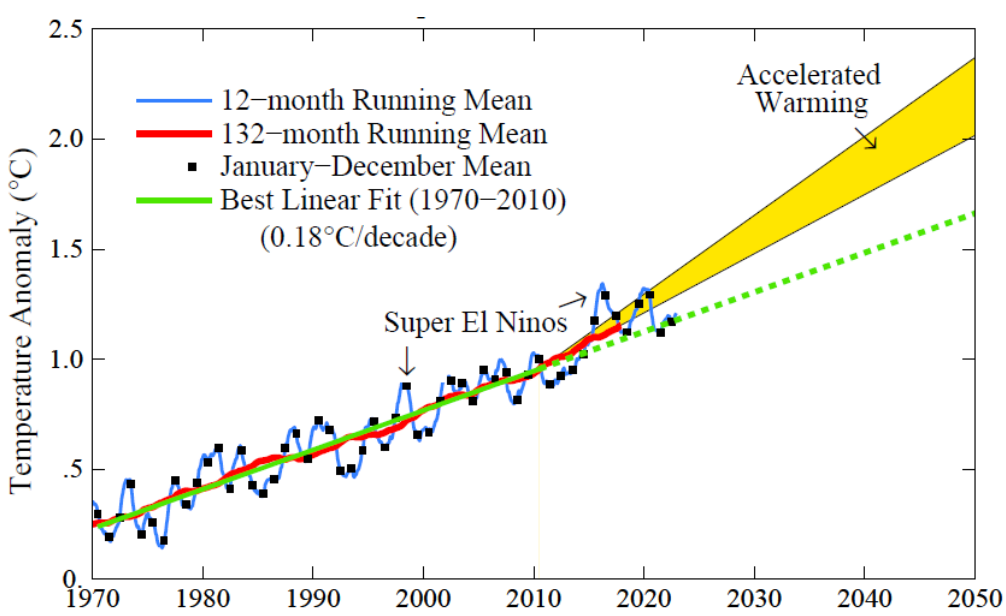

Fig. 4. Global surface temperature relative to 1880-1920 average. The 12-month running-mean extends through May 2023.

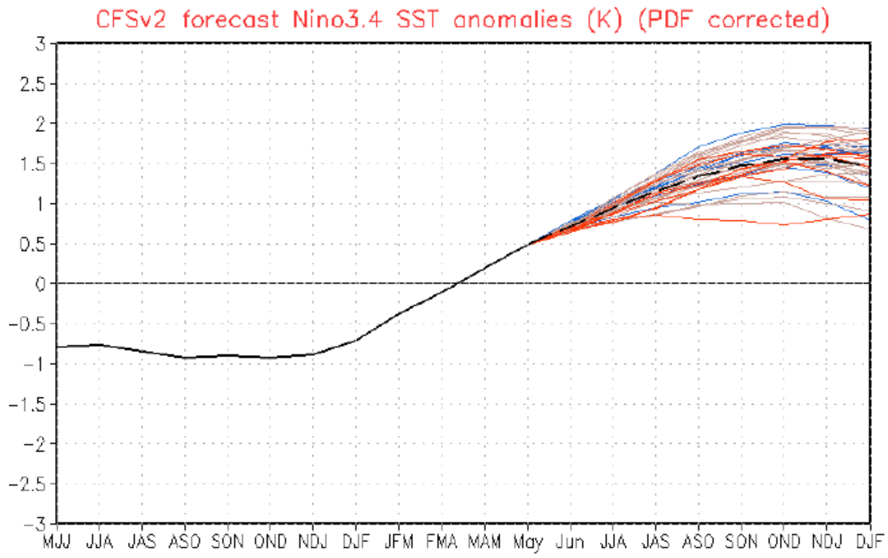

Fig. 5. NCEP forecasts[9] of Nino3.4 in June 2023. El Nino is indicated by a value > +0.5°C.

The current NCEP forecast (Fig. 5) has a Nino3.4 peak at only about 1.5°C, which would not be a super El Nino, but some other models predict a strong El Nino, comparable to those in 1997 and 2016, which are described as super El Ninos. The expectation that aerosols will decline moderately during the next few decades is based on the assumption that the world will trend toward clean energy sources that emit fewer aerosols than fossil fuels. Aerosol sources are complex, however, and include fires that may increase with global warming. It is unfortunate that we are not monitoring the global aerosol climate forcing; that is difficult because it requires precise global measurements of aerosol and cloud microphysics; we knew how to do that in 1990,[10] but chose not to initiate such a monitoring system.

Finally, we note that these topics are discussed in plain language in a prior communication.[11] The distinction between equilibrium warming (which is approximately 10°C for present atmospheric composition) and committed warming (which is a more complex matter that depends on ocean and ice sheet response times and on the rate of future greenhouse gas emissions) is discussed in that communication, where we also explain that we prefer to work on advancing the science, rather than engage in Twitter wars about the difference between equilibrium warming and committed warming. The difference between equilibrium and committed warmings is also discussed in a recent communication.[12]

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[1] NOAA requires NINO3.4 to exceed 0.5°C for 5 consecutive overlapping 3-month periods to qualify as an El Nino.
[2] Global warming acceleration plus miscellaneous, 15 October 2018 communication.
[3] Draft paper submitted to Oxford Open Climate Change. The paper is undergoing revisions. Comments and criticisms are solicited, but we do not intend to release subsequent versions of the paper until it is published.
[4] Hansen, J., 2009: *Storms of My Grandchildren*, Bloomsbury, New York, 320 pages.
[5] Global temperature in 2022, 12 January 2023 communication.
[6] Temperature anomaly in an equatorial Pacific region relative to the mean for 1990-2020.
[7] Loeb, N. G., Johnson, G. C., Thorsen, T. J., Lyman, J. M., Rose, F. G., & Kato, S., Satellite and ocean data reveal marked increase in Earth's heating rate, *Geophys. Res. Lett.* **48**, e2021GL093047, 2021.
[8] von Schuckmann K, Cheng L, Palmer MD *et al.* Heat stored in the Earth system: where does the energy go?, *Earth System Science Data* 2020;**12**:2013-41

[9] NOAA National Center for Environmental Prediction forecasts are available and updated weekly. A new ensemble of climate model runs is made each week. Chart 24 in their Weekly ENSO Evolution, Status and Prediction shows the average of other global atmosphere-ocean models as “DYN AVG.”

[10] Hansen, J., W. Rossow and I. Fung, Long-Term Monitoring of Global Climate Forcings and Feedbacks, NASA CP-3234, 91 pages, 1993

[11] Hansen, J., M. Sato, N. Loeb, L. Simons and K. von Schuckmann, Earth’s energy imbalance and climate response time, 22 December 2022

[12] Equilibrium warming = committed warming? 25 May 2023 communication.