Global Temperature in 2018 and Beyond

06 February 2019

James Hansen[a], Makiko Sato[a], Reto Ruedy[b,c] Gavin A. Schmidt[c], Ken Lo[b,c]

Abstract. **Global surface temperature in 2018 was the 4th highest in the period of instrumental measurements in the Goddard Institute for Space Studies (GISS) analysis. The 2018 global temperature was +1.1°C (~2°F) warmer than in the 1880-1920 base period; we take that base period as an estimate of 'pre-industrial' temperature. The four warmest years in the GISS record all occur in the past four years, and the 10 warmest years are all in the 21st century. We also discuss the prospects for near-term global temperature change.**

Update of the GISS (Goddard Institute for Space Studies) global temperature analysis (GISTEMP)[1,2] (Fig. 1), finds 2018 to be the 4th warmest year in the instrumental record. More detail is available at http://data.giss.nasa.gov/gistemp/ and http://www.columbia.edu/~mhs119/Temperature. Figures shown here are available from Makiko Sato on the latter web site.

We use 1880-1920 as baseline, i.e., as the zero-point for temperature anomalies, in part because it is the earliest period with substantial global coverage of instrumental measurements. Global temperature in 1880-1920 should approximate 'preindustrial' temperature, because the small warming from human-made greenhouse gases in that period tends to be offset by unusually high volcanic activity then[3].

The four warmest years in the GISS record are the past four years, 2015-2018. Figure 2 compares the temperature anomalies for each of these years relative to the 1951-1980 base period. We use this recent base period for global maps because it allows good global coverage, including data for Antarctica.

The strong 2015-16 El Niño in the equatorial Pacific Ocean is more prominent in the annual 2015 map than in 2016, yet the impact of the El Niño on global temperature is greater in 2016. This is a result of the lag of 3-4 months between El Niños and their effect on global temperature.

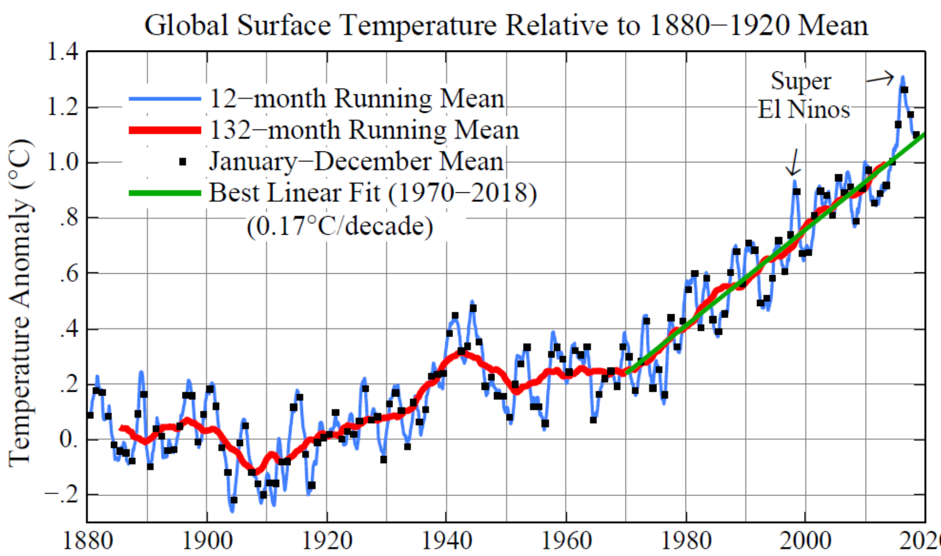

Fig. 1. Global surface temperatures relative to 1880-1920 based on GISTEMP data, which employs GHCN.v3 for meteorological stations, NOAA ERSST.v5 for sea surface temperature, and Antarctic research station data[1].

[a] Earth Institute, Columbia University, New York, NY
[b] SciSpace LLC, New York, NY
[c] NASA Goddard Institute for Space Studies, New York, NY

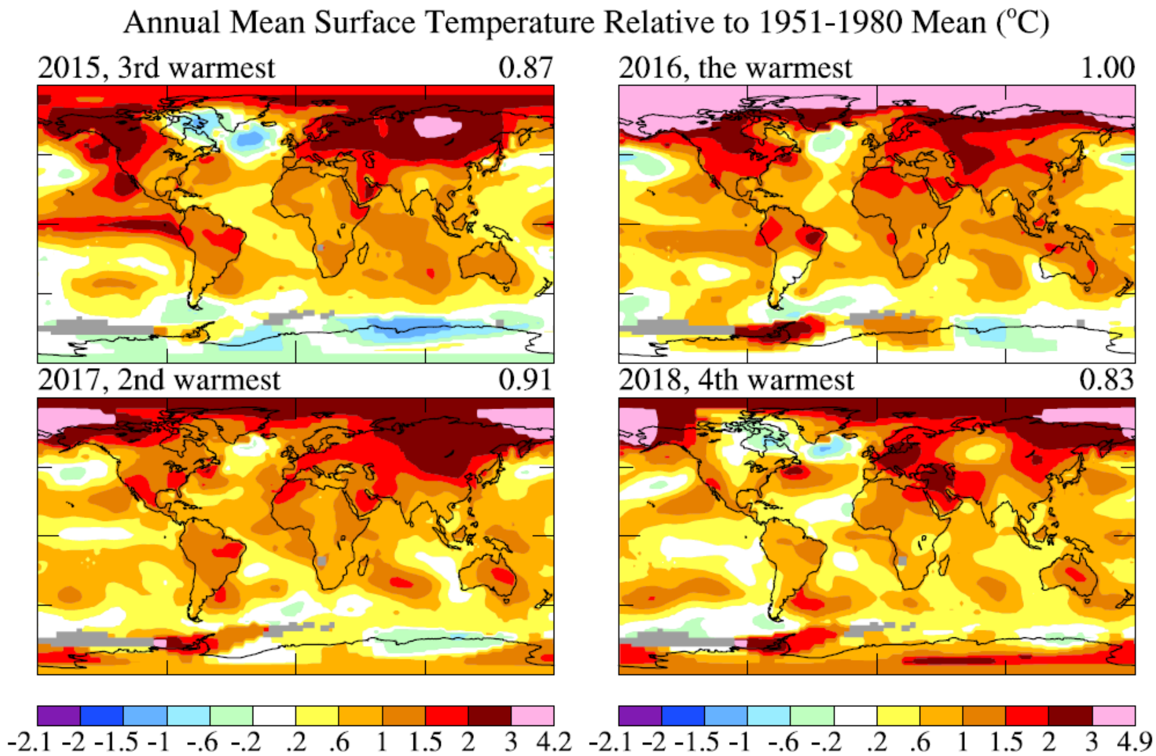

Fig. 2. Temperature anomalies in the past four years relative to the 1951-1980 base period. We use the 1951-1980 base period for maps because of more limited global data coverage in 1880-1920.

Global land area has warmed about twice as much as global ocean, as shown in Figure 3. Linear fit to the period 1975-present yields a warming about 1.6°C over land and 08°C over ocean. Thus average warming of land is about 3°F and ocean surface warming is about 1.5°F. The warming is reaching levels at which it becomes easier for the public to appreciate that the warming is significant.

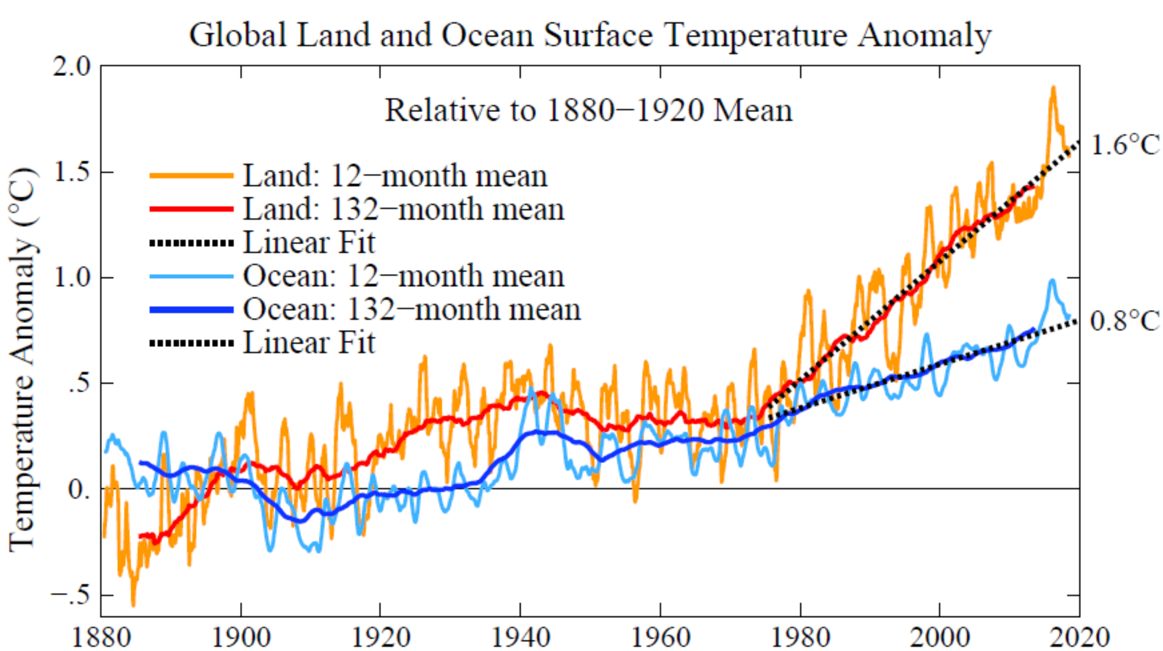

Fig. 3. Temperature anomalies relative to 1880-1920 for global land and global ocean areas.

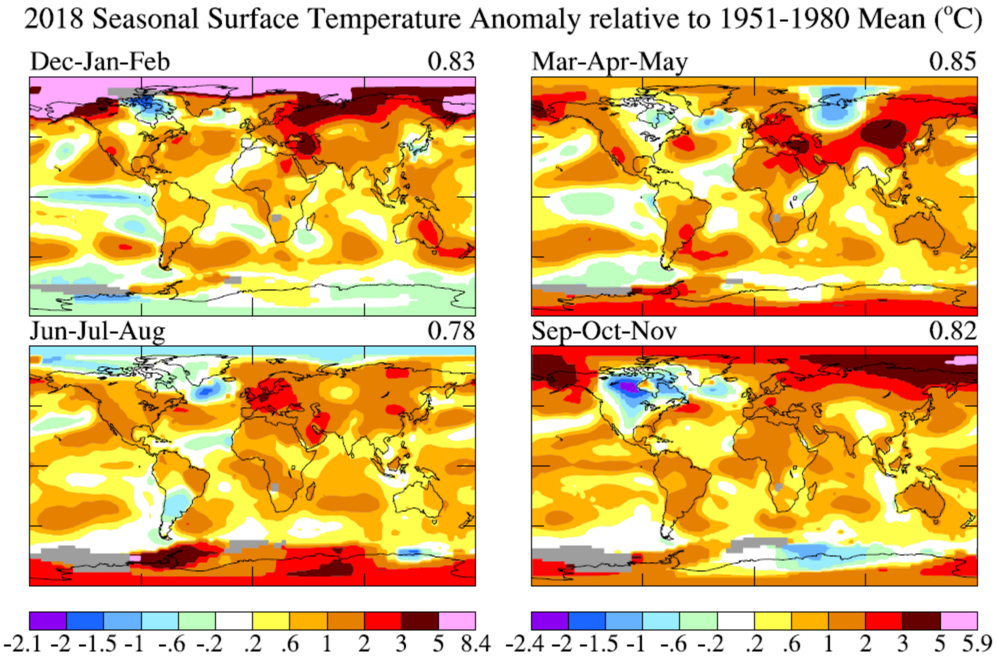

Fig. 4. Temperature anomalies in the past four seasons relative to the 1951-1980 base period.

What can we say about the prospects for continued temperature change in 2019 and the next few years? Interannual variability tends to be dominated by the tropical Southern Oscillation, the El Niño/La Niña cycle. During 2018 the tropics have moved from the La Niña phase (upper left map in Figure 4) to a weak El Niño (lower right map in Figure 4). NOAA predicts a 65% chance that the tropical warmth will continue at least through the coming Northern Hemisphere spring and be classified as an El Niño. However, models show a broad range of possibilities for the development of tropical temperature; some models have the weak El Niño-like warmth fading rapidly in 2019. The El Niño situation will become clear during the next few months. If a substantial El Niño develops, 2019 global temperature is expected to rise, although it is unlikely that the El Niño will approach the strength of the 2015-16 El Niño.

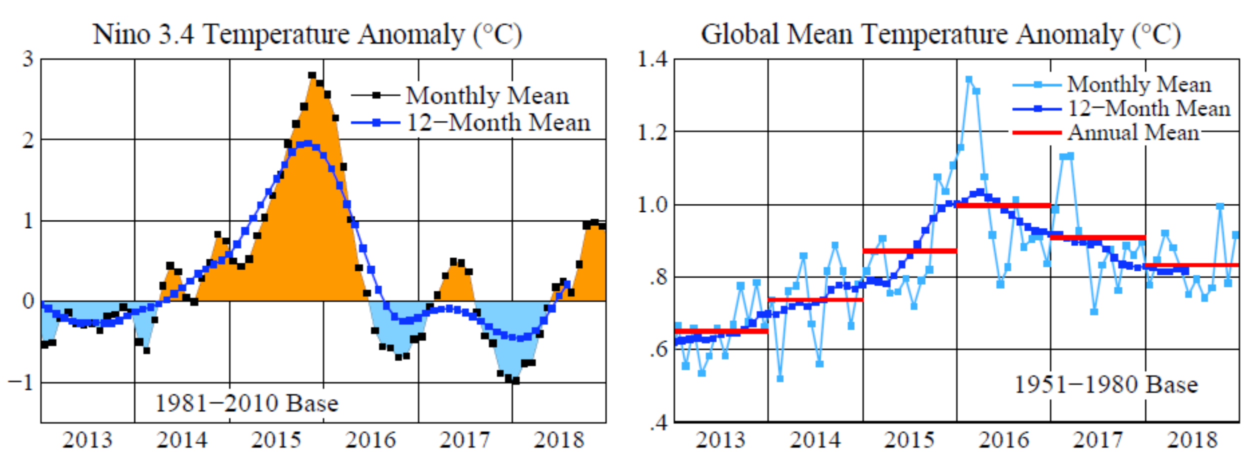

Fig. 5. Temperature anomalies since 2013 in the Niño 3.4 region and globally

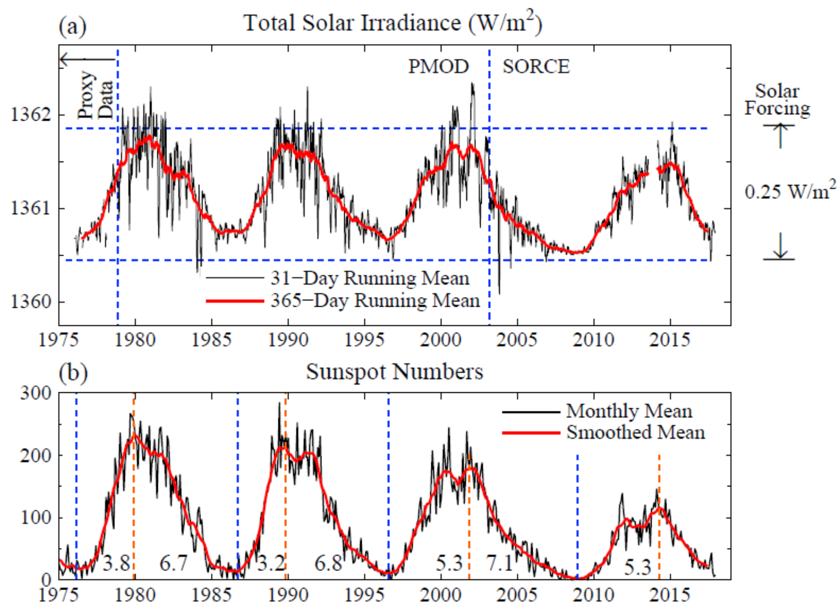

Fig. 6. Solar irradiance and sunspot number in the era of satellite data. Left scale is the energy passing through an area perpendicular to Sun-Earth line. Averaged over Earth's surface the absorbed solar energy is ~240 W/m^2, so the full amplitude of the measured solar variability is ~0.25 W/m^2.

Continuing changes in global climate forcings also affect global temperature. The record 2016 global temperature was abetted by its near coincidence with a solar maximum (Figure 6). Climate forcing by greenhouse gases (GHGs) is the dominant drive for climate change, because it is continually increasing, but changing solar irradiance is not a negligible factor. It has been argued that the coming Solar Minimum could be prolonged with the irradiance declining below its range so far in the era of accurate satellite data, analogous to the Maunder Minimum of 1645-1715 (Eddy, 1976)[4] when sunspots supposedly were almost absent. The next few years of solar irradiance data may be particularly informative.

Earth's energy imbalance, estimated to be[3] currently +0.75 ± 0.25 W/m^2, is the proximate cause of continued ocean warming and tends to dominate global surface temperature change on decadal and longer time scales. However, global surface temperature on shorter periods is affected by the rate of change of radiative forcings as well as the Southern Oscillation. We plan to write a Communication on this topic within several months, after the El Niño situation becomes clearer.

References

[1] Hansen, J., R. Ruedy, M. Sato, and K. Lo, 2010: Global surface temperature change. *Rev. Geophys.*, **48**, RG4004, doi:10.1029/2010RG000345.

[2] The current GISS analysis employs NOAA ERSST.v5 for sea surface temperature, GHCN.v.3.3.0 for meteorological stations, and Antarctic research station data, as described in reference 1.

[3] Hansen, J., M. Sato, P. Kharecha, K. von Schuckmann, D.J. Beerling, J. Cao, S. Marcott, V. Masson-Delmotte, M.J. Prather, E.J. Rohling, J. Shakun, P. Smith, A. Lacis, G. Russell, and R. Ruedy, 2017: Young people's burden: Requirement of negative CO_2 emissions. *Earth Syst. Dynam.*, **8**, 577-616, doi:10.5194/esd-8-577-2017.

[4] Eddy, J.A., 1976: The Maunder Minimum, *Science*, **192**, 1189-1202.