GISS 2007 Temperature Analysis

The year 2007 tied for second warmest in the period of instrumental data, behind the record warmth of 2005, in the Goddard Institute for Space Studies (GISS) analysis. 2007 tied 1998, which had leapt a remarkable 0.2°C above the prior record with the help of the “El Nino of the century”. The unusual warmth in 2007 is noteworthy because it occurs at a time when solar irradiance is at a minimum and the equatorial Pacific Ocean is in the cool phase of its natural El Nino – La Nina cycle.

Figure 1 shows 2007 temperature anomalies relative to the 1951-1980 base period mean. The global mean temperature anomaly, 0.57°C (about 1°F) warmer than the 1951-1980 mean, continues the strong warming trend of the past thirty years that has been confidently attributed to the effect of increasing human-made greenhouse gases (GHGs) (http://pubs.giss.nasa.gov/docs/2007/2007_Hansen_etal_1.pdf). The eight warmest years in the GISS record have all occurred since 1998, and the 14 warmest years in the record have all occurred since 1990.

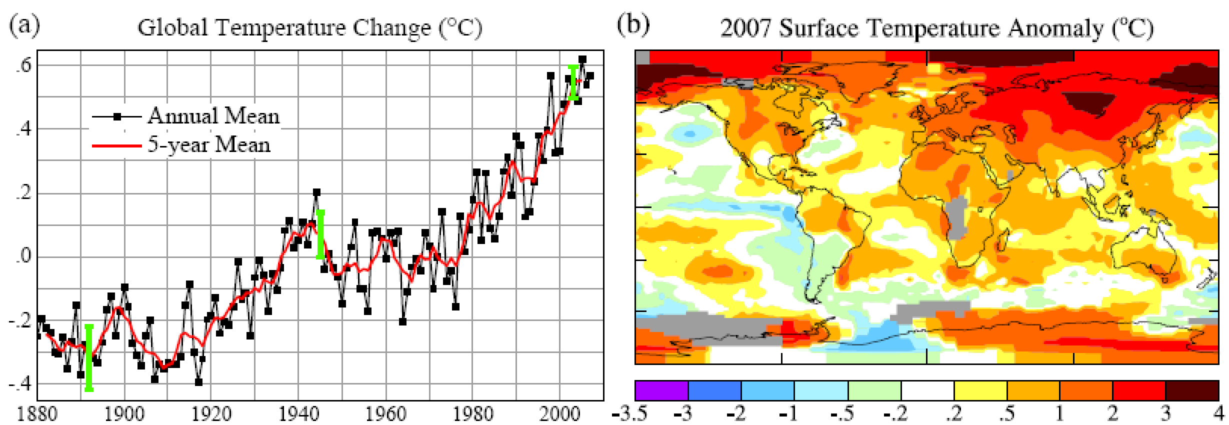

Figure 1. (a) Annual surface temperature anomaly relative to 1951-1980 mean, based on surface air measurements at meteorological stations and ship and satellite measurements of sea surface temperature. (b) Global map of surface temperature anomalies for 2007.

Arctic Warmth. The map reveals that the greatest warming has been in the Arctic and neighboring high latitude regions. Polar amplification is an expected characteristic of global warming, as the loss of ice and snow engenders a positive feedback via increased absorption of sunlight. The large Arctic warm anomaly of 2007 is consistent with observed record low Arctic sea ice cover in September 2007.

El Nino-La Nina Cycle. The cooler than normal equatorial region just to the west of South America is a reflection of the ongoing La Nina phase of a phenomenon dubbed the Southern Oscillation. In the La Nina phase of the El Nino-La Nina cycle the equatorial winds in the Pacific Ocean blow with stronger than average force from the east, driving warm surface waters toward the Western Pacific. This induces upwelling of cold deep water near Peru, which then spreads westward along the equator.

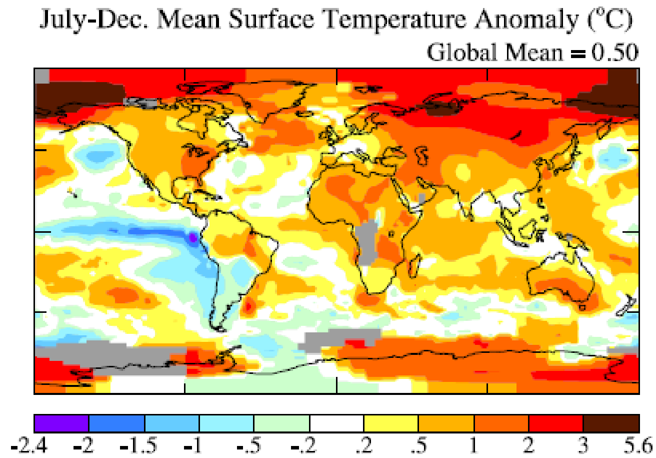

Figure 2. Surface temperature anomalies for July-December 2007.

Figure 2, the surface temperature anomaly for July-December, shows that the La Nina equatorial cooling is strong in the second half of the year. The La Nina should thus continue to affect global temperatures into 2008.

Solar Variability. The sun is another source of natural global temperature variability. Figure 3, based on an analysis of satellite measurements by Richard Willson, shows that 2007 is at the minimum of the current 10-11 year solar cycle. Another analysis of the satellite data (not illustrated here), by Judith Lean, has the 2007 solar irradiance minimum slightly lower than the two prior minima in the satellite era. The differences between the two analyses are a result primarily of the lack of accurate absolute calibrations and inadequate overlap of measurements by successive satellites.

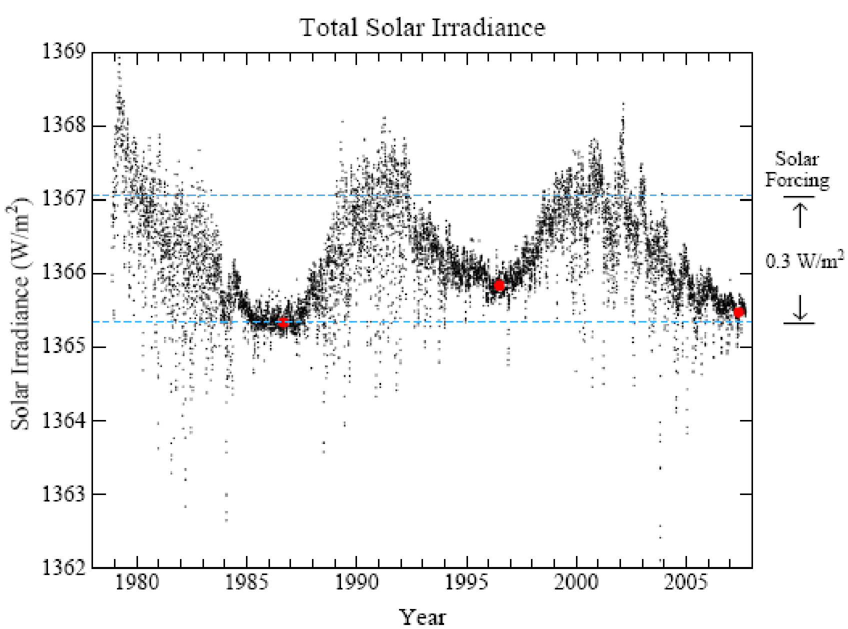

Figure 3. Solar irradiance from analysis of satellite measurements by Willson and Mordvinov (Geophys. Res. Lett., 2003) and update.

This cyclic solar variability yields a climate forcing change of about 0.3 W/m^2 between solar maxima and solar minima. [Although solar irradiance of an area perpendicular to the solar beam is about 1366 W/m^2, the absorption of solar energy averaged over day and night and the Earth's surface is about 240 W/m^2.] Several analyses have extracted empirical global temperature variations of amplitude about 0.1°C associated with the 10-11 year solar cycle, a magnitude consistent with climate model simulations, but this signal is difficult to disentangle from other causes of global temperature change including unforced chaotic fluctuations.

The solar minimum forcing is thus about 0.15 W/m^2 relative to the mean solar forcing. For comparison, the human-made GHG climate forcing is now increasing at a rate of about 0.3 W/m^2 per decade (http://pubs.giss.nasa.gov/docs/2004/2004_Hansen_Sato.pdf). If the sun were to remain 'stuck' in its present minimum for several decades, as has been suggested (http://news.independent.co.uk/sci_tech/article3223603.ece) in analogy to the solar Maunder Minimum of the seventeenth century, that negative forcing would be balanced by a 5-year increase of GHGs. Thus, in the current era of rapidly increasing GHGs, such solar variations cannot have a substantial impact on long-term global warming trends. Furthermore, recent sighting of the first sunspot of reversed polarity (http://spaceweather.com/archive.php?view=1&day=04&month=01&year=2008) and (http://www.noaanews.noaa.gov/stories2008/20080104_sunspot.html) signifies that the ~ 4-year period of increasing solar irradiance is about to get underway.

Summary. The Southern Oscillation and the solar cycle have significant effects on year-to-year global temperature change. Because both of these natural effects were in their cool phases in 2007, the unusual warmth of 2007 is all the more notable. It is apparent that there is no letup in the steep global warming trend of the past 30 years (see 5-year mean curve in Figure 1a).

"Global warming stopped in 1998" has become a recent mantra of those who wish to deny the reality of human-caused global warming. The continued rapid increase of the five-year running mean temperature exposes this assertion as nonsense. In reality, global temperature jumped two standard deviations above the trend line in 1998 because the "El Nino of the century" coincided with the calendar year, but there has been no lessening of the underlying warming trend.

Global predictions. The quasi-regularity of some natural climate forcing mechanisms, combined with knowledge of human-made forcings, allows projection of near-term global temperature trends with reasonably high confidence. Prediction for a specific year is a bit hazardous, as evidenced by an incorrect prediction of record global warmth made by the British climate analysis group for 2007. Such speculations are useful, as they draw attention to the mechanisms, and allow testing of understanding. Presumably part of the basis for their prediction was an assumption of a continued warming contribution from the 2006 El Nino. However, evidence of El Nino warmth disappeared very early in 2007.

Solar irradiance will still be on or near its flat-bottomed minimum in 2008. Temperature tendency associated with the solar cycle, because of the Earth's thermal inertia, has its minimum delayed by almost a quarter cycle, i.e., about two years. Thus solar change should not contribute significantly to temperature change in 2008.

La Nina cooling in the second half of 2007 (Figure 2) is about as intense as the regional cooling associated with any La Nina of the past half century, as shown by comparison to Plate 9 in Hansen et al. (http://pubs.giss.nasa.gov/docs/1999/1999_Hansen_etal.pdf) and updates to Plate 9 on the GISS web site. Effect of the current La Nina on global surface temperature is likely to continue for at least the first several months of 2008. Based on sequences of Pacific Ocean surface temperature patterns in Plate 9, a next El Nino in 2009 or 2010 is perhaps the most likely timing. But whatever year it occurs, it is a pretty safe bet that the next El Nino will help carry global temperature to a significantly higher level.

Competing with the short-term solar and La Nina cooling effects is the long-term global warming effect of human-made GHGs. The latter includes the trend toward less Arctic sea ice that markedly increases high latitude Northern Hemisphere temperatures. Although sea ice cover fluctuates from year to year, the large recent loss of thick multi-year ice implies that this warming effect at high latitudes should persist.

Based on these considerations, it is unlikely that 2008 will be a year with an unusual global temperature change, i.e., it is likely to remain close to the range of (high) values exhibited in 2002-2007. On the other hand, when the next El Nino occurs it is likely to carry global temperature to a significantly higher level than has occurred in recent centuries, probably higher than any year in recent millennia. Thus we suggest that, barring the unlikely event of a large volcanic eruption, a record global temperature clearly exceeding that of 2005 can be expected within the next 2-3 years.

<u>Data flaw</u>. Finally, we note that a minor data processing error found in the GISS temperature analysis in early 2007 does not affect the present analysis. The data processing flaw was failure to apply NOAA adjustments to United States Historical Climatology Network stations in 2000-2006, as the records for those years were taken from a different data base (Global Historical Climatology Network). This flaw affected only 1.6% of the Earth's surface (contiguous 48 states) and only the several years in the 21st century. As shown in Figure 4 and discussed elsewhere (http://www.columbia.edu/~jeh1/distro_realdeal.16aug20074.pdf), the effect of this flaw was immeasurable globally (~0.003°C) and small even in its limited area. Contrary to reports in certain portions of the media, the data processing flaw did not alter the ordering of the warmest years on record. Obviously the global ranks were unaffected. In the contiguous 48 states the statistical tie among 1934, 1998 and 2005 as the warmest year(s) was unchanged. In the current analysis, in the flawed analysis, and in the published GISS analysis (http://pubs.giss.nasa.gov/docs/2001/2001_Hansen_etal.pdf), 1934 is the warmest year in the contiguous states (not globally) but by an amount (magnitude of the order of 0.01°C) that is an order of magnitude smaller than the uncertainty.

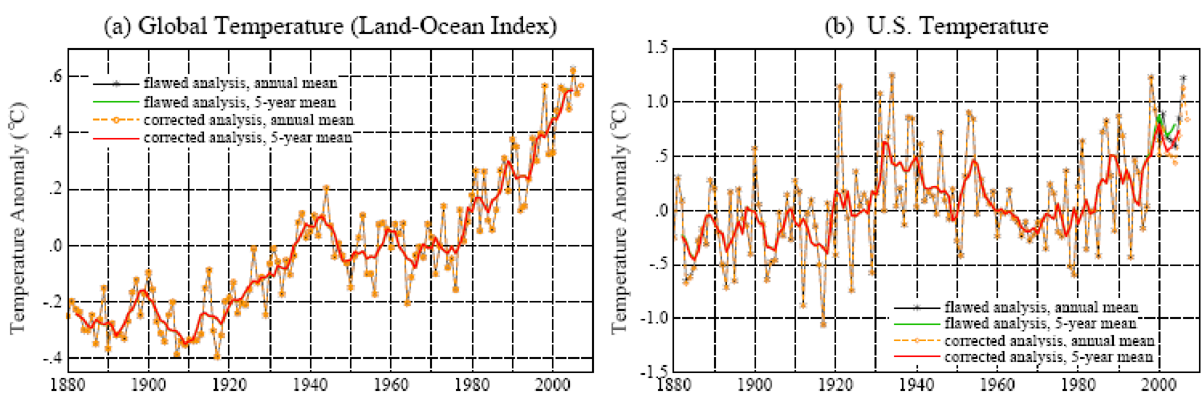

Figure 4. Global and U.S. temperatures with and without the data processing flaw.