Global Temperature in 2015

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Abstract. **Global surface temperature in 2015 was +0.87°C (~1.6°F) warmer than the 1951-1980 base period in the GISTEMP analysis, making 2015 the warmest year in the period of instrumental data. The 2015 temperature was boosted by a strong El Niño, nearly of the same strength as the 1998 "El Niño of the century". The updated global temperature record makes it clear that there was no global warming "hiatus". Global temperature in 2015 was +1.13 (~2.03°F) relative to the 1880-1920 mean. Accounting for interannual variability, it is fair to say that global warming has now reached ~1°C, almost ~2°F.**

Update of the GISS (Goddard Institute for Space Studies) global temperature analysis (GISTEMP)[1,2] (Fig. 1a), finds 2015 to be the warmest year in the instrumental record. (More detail is available at http://data.giss.nasa.gov/gistemp/ and http://www.columbia.edu/~mhs119/; figures in this summary are available from Makiko Sato on the latter web site.) Unlike the prior three record years, 2014, 2010 and 2005, each of which exceeded the preceding record by only a few hundredths of a degree, 2015 smashed the prior record by more than 0.1°C. The only prior record-raising jump of annual global temperature as large, probably slightly larger, was in 1998. The 1998 temperature was boosted by the strong 1997-98 "El Niño of the century."[3] The 2015 temperature was boosted by an El Niño of comparable magnitude.

The high 2015 global temperature should practically terminate discussion of a hypothesized "global warming hiatus", as the past two warm years remove the impression that warming has plateaued (Fig. 1). Close examination (Fig. 1b) reveals that the warming rate of the past decade is less than in the prior 30 years, but such fluctuations are not unusual and can be accounted for by a combination of factors[4].

The present GISTEMP analysis uses the NOAA ERSST.v4 (Extended Reconstructed Sea Surface Temperature, Version 4)[5] for ocean surface temperatures. Principal change in v4, relative to v3 that was used in recent years, is a revision of the ship SST bias adjustment, which Huang et al.[5] well justify. v4 results in a small increase (a few hundredths of a degree) in the global warming of the past half century.

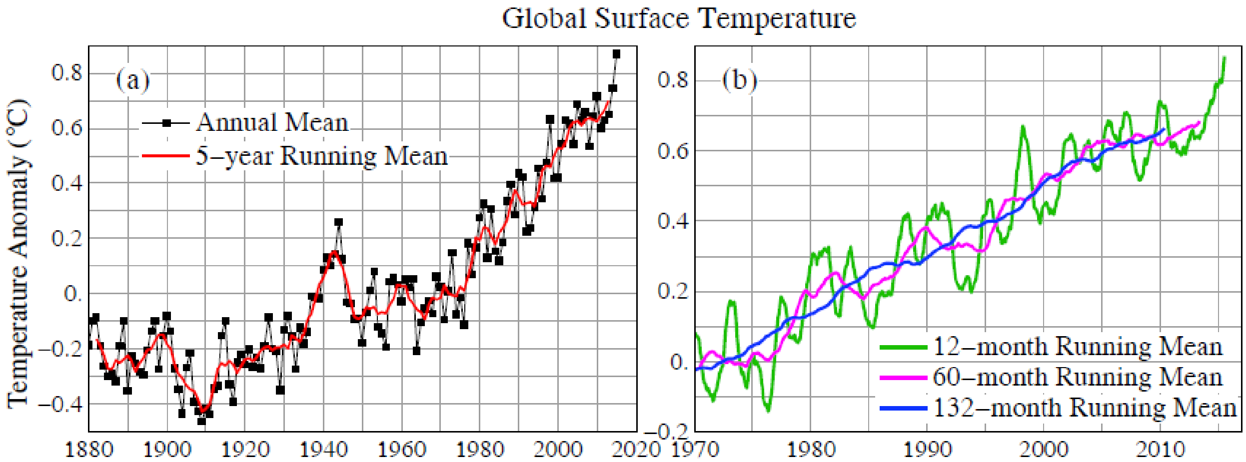

Fig. 1. Global surface temperatures relative to 1951-1980 in the GISTEMP analysis, which employs GHCN.v3 for meteorological stations, NOAA ERSST.v4 for sea surface temperature, and Antarctic research station data[1].

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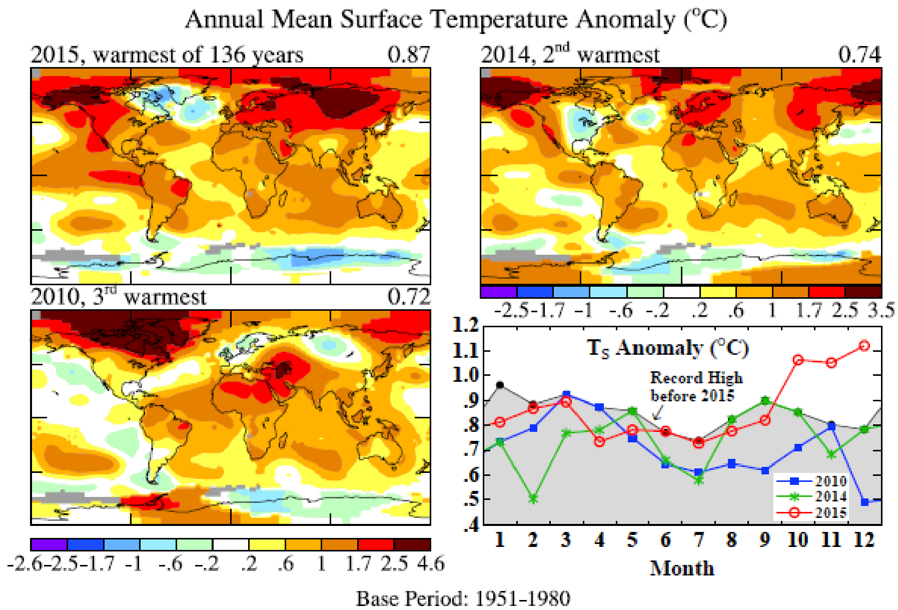

Fig. 2. Temperature anomalies in the three warmest years and their monthly global anomalies.

ERSST.v4 also causes the warming peak in the 1940s to become more prominent. Although the 1940s warming peak is surely real, Hansen and Sato[6] suggest that it is exaggerated by bias introduced by discontinuities in data associated with World War II ship records, as a substantial portion of the warming spike in the ERSST.v4 data arises from an apparent sudden, probably unphysical, warming of the ocean in the Southern Hemisphere during WW II and then a sudden cooling at the end of WW II (Fig. 5 of reference 6). Such data issues are inherent during a time when limited measurements make it difficult if not impossible to make accurate homogeneity adjustments. We point out the issue here because of frequently asked question about how such a large sudden global warming could have occurred in the absence of known large climate forcings. An important point to note is that the homogeneity of measurement systems and global coverage is substantially improved during the past half century of rapid global warming. Smaller data issues remain in the recent global temperature record, but these are mainly at levels not larger than several hundredths of a degree.

All land area with substantial habitation was warmer than the 1951-1980 climatology in 2015 (upper left of Fig. 2). The final three months of 2015 each exceeded the prior monthly global temperature record by a wide margin (lower right of Fig. 2). The late-2015 record warmth was spurred by a strong El Niño (Fig. 3). Global temperature anomaly, averaged over many El Niños, is strongly correlated with Niño3.4

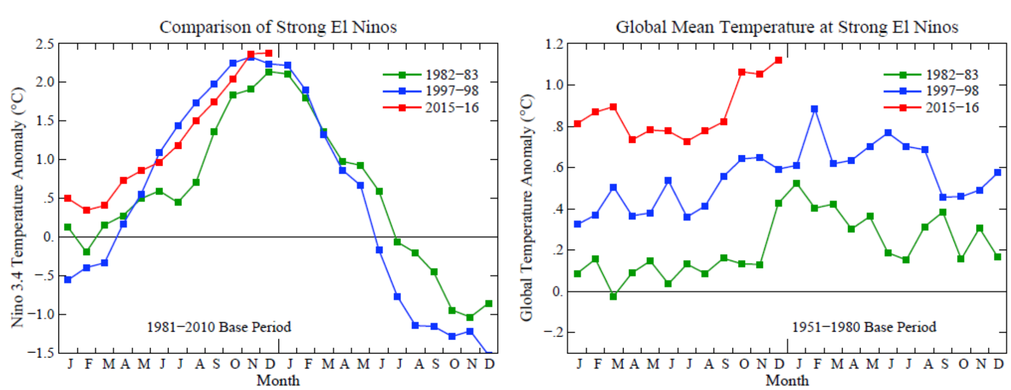

Fig. 3. Temperature anomalies in Niño3.4 region[3] for three strongest El Niños in past 100 years and corresponding global temperature anomalies. Data source for (a) http://www.cpc.ncep.noaa.gov/data/indices/ersst4.nino.mth.81-10.ascii

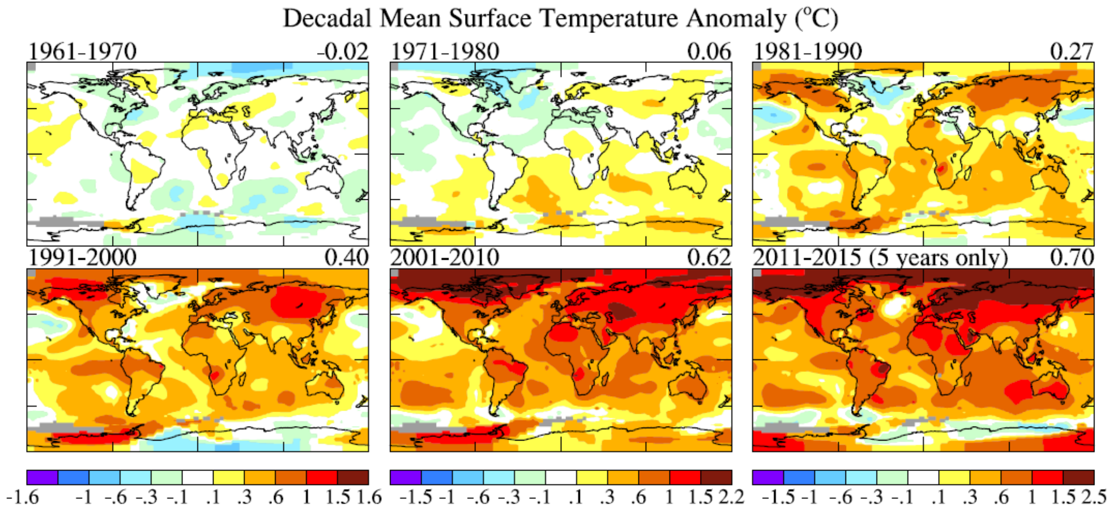

Fig. 4. Decadal surface temperature anomalies relative to 1951-1980 base period.

temperature anomaly, with global temperature lagging Niño3.4 anomaly by ~3 months. Thus we can anticipate that 2016 will again be very warm on global average, as temperature in the first half of the year will be boosted by the fading El Niño and Earth's continuing average energy imbalance[7,8] of 0.5-1 W/m^2 also creates a tendency toward warming. Thus we can say with confidence that both 60-month (5-year) and 128-month (11-year) running means in Fig. 1b will continue to rise noticeably in 2016.

We can also say with confidence, because of Earth's energy imbalance (energy absorbed from sunlight exceeding heat radiated to space), that the present decade will be warmer than last decade. Already the first half of the present decade is almost 0.1°C warmer than last decade (Fig. 4). Strong La Niñas commonly follow strong El Niños, so it is likely that 2017 and perhaps 2018 will be quite cool relative to 2015-2016, but the decade as a whole should be considerably warmer than the prior decade.

Local temperatures are much less predictable, especially on the seasonal and shorter time scales that people care about most, as illustrated by the 2015 daily temperature record for New York City (Fig. 5). For about one month beginning in early February 2015 the daily high temperature almost never reached the long-term daily average temperature for that date (Fig. 5), making it the coldest spell in the memory of many New Yorkers. In contrast, December 2015 was so warm that the lowest daily temperature almost never reached the long-term daily average temperature. Unlike this extreme variability in winter, the

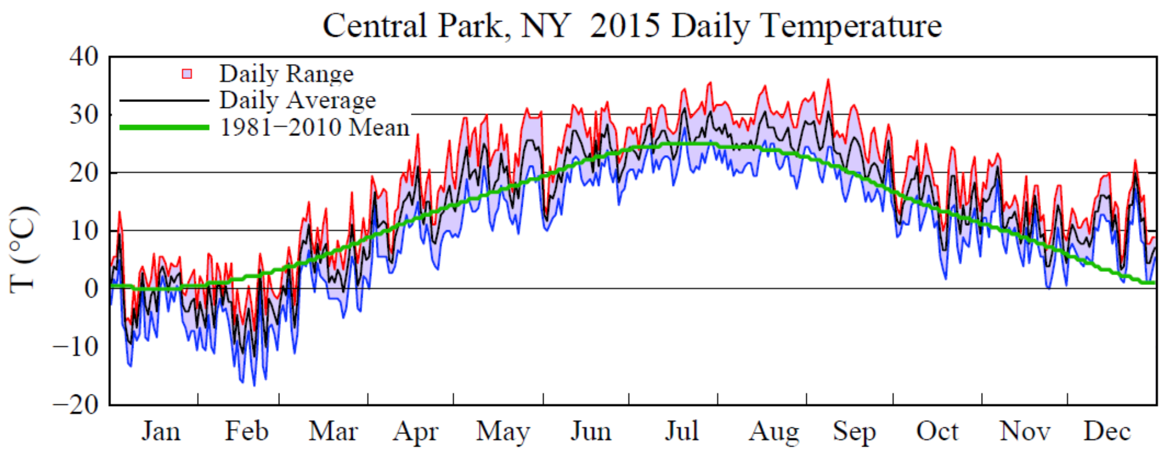

Fig. 5. Daily temperatures in Central Park, New York City, during 2015. Data source: NOAA National Weather Service New York Office http://w2.weather.gov/climate/index.php?wfo=okx

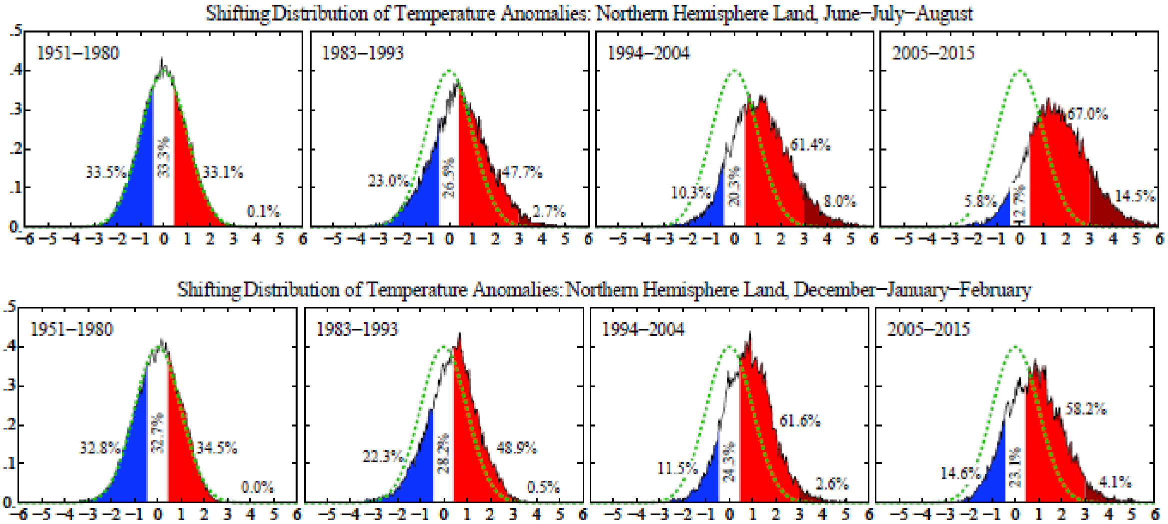

Fig. 6. Frequency of occurrence (vertical axis) of local seasonal mean temperature anomalies in unit of local standard deviation of Northern Hemisphere land areas. Upper row is for summer and lower row for winter.

summer temperatures in New York City hued much closer to the long-term (Fig. 5), but with a noticeable warming in the second half of the summer relative to even a fairly recent base period, 1981-2010 (Fig. 5).

New York City experience in 2015 is not atypical of other Northern Hemisphere locations, as shown by the bell curves in Fig. 6. The frequency distribution of summer mean temperature anomalies in Northern Hemisphere land areas has shifted by more than one standard deviation in the past decade relative to the bell curve of natural variability in the base period 1951-1980. Almost every summer now falls in a category that was considered to be significantly warmer than average during 1951-1980. On the other hand, the shift of the winter bell curve (lower half of Fig. 6) is notably smaller, which makes it difficult for people to notice a significant effect of global warming on winter temperature. The bell curve shift is smaller in the winter, not because warming is smaller then, but because of larger winter variability.

Given the conclusion that decade to decade warming in the near term is practically built in by the planet's energy imbalance, and combining this with the fact that the summer bell curve is already shifted rather dramatically, suggests that we should be close to a time that global warming becomes obvious to most of the public. Although we have not done a scientific study of the following, it seems to us that perhaps the most notable characteristic of warming has been a stretching of the period of summer-like temperatures. Fig. 5 presents a clear example of this in 2015 in New York, as summer-like temperatures were reached by early May and summer temperatures, reaching 30°C (86°F) or higher, extended into September.

Almost finally, for fun and for education, we repeat a figure (Fig. 7) from last year's temperature update[9] showing El Niño predictions that were available at that time. All of the models save two predicted that the very weak tropical warming underway at that time would fade away over the summer and fall. Two models, the NCEP (NOAA's National Centers for Environmental Protection) and LDEO (Columbia University's Lamont Doherty Earth Observatory) models, essentially got it right, predicting the Niño3.4 temperature to bottom out in late winter and then a strong El Niño to begin to grow over the summer and presumably peak in the early winter as El Niños usually do. It should be useful now to figure out why most models went wrong and two got it right – perhaps that has already been done.

Fig. 8 is an expanded view of recent global temperatures and the table ranks them

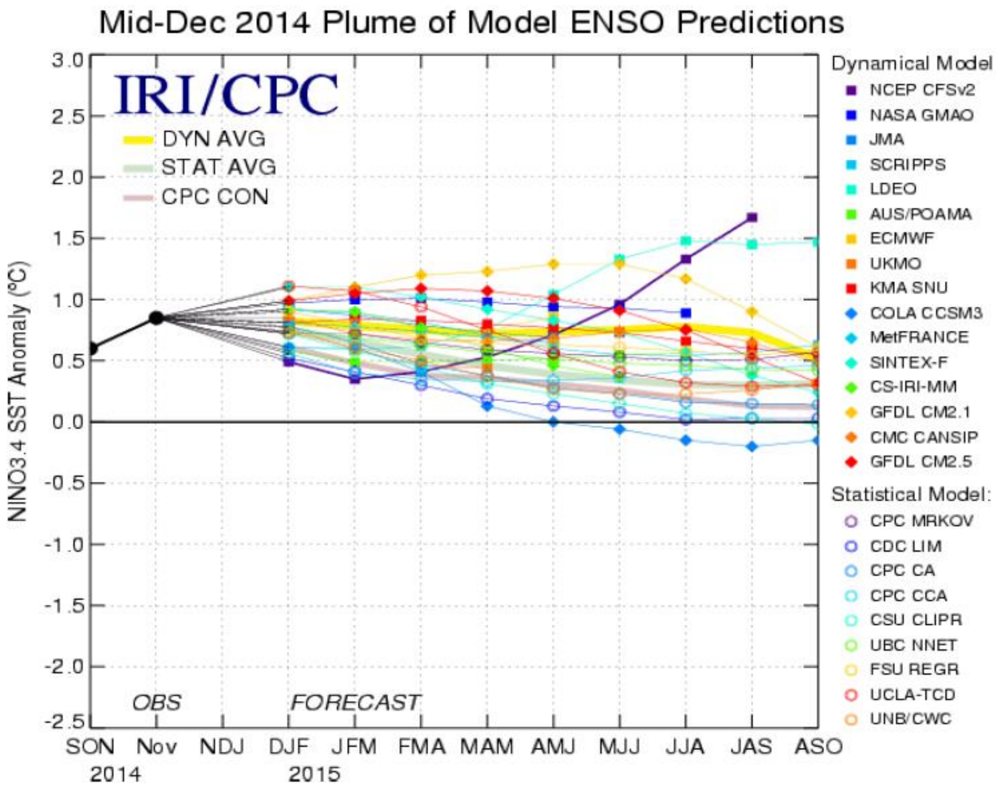

Fig. 7. IRI/CPC Pacific Niño 3.4 SST Model Outlook (http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml#discussion).

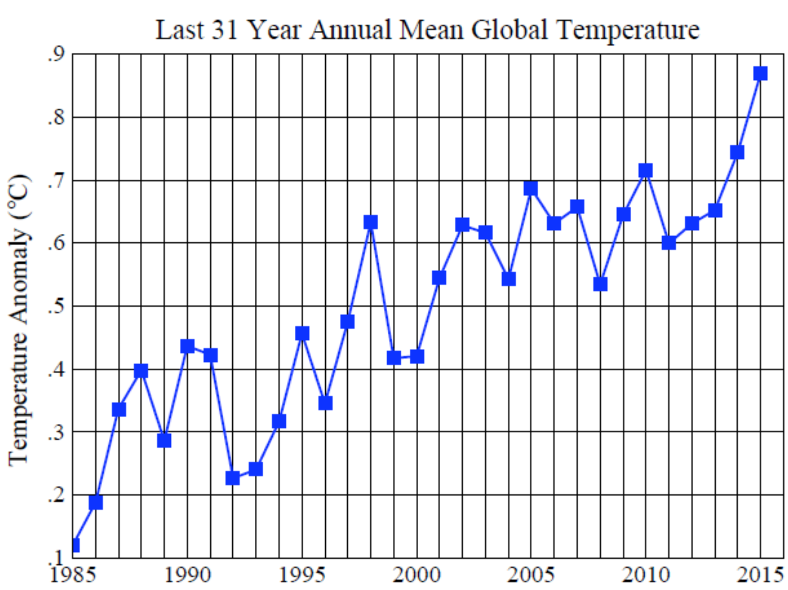

Fig. 8. Expanded recent temperatures to clarify year-to-year changes.

Appendix

Table 1. Rankings of annual global temperature in the GISTEMP analysis.

Year	Anomaly	Rank
2015	0.87	#1
2014	0.74	
2010	0.72	~Tie #2-4
2005	0.69	
2007	0.66	
2013	0.65	
2009	0.64	
1998	0.63	~Tie #5-11
2002	0.63	
2006	0.63	
2012	0.63	

References

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[2] The current GISS analysis employs NOAA ERSST.v4 for sea surface temperature, GHCN.v.3.3.0 for meteorological stations, and Antarctic research station data, as described in reference 1.

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