

## How Much Has The Earth Warmed Since Pre-industrial Times?

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This seems like a simple question – just pick a date for the end of “pre-industrial times” and subtract the temperature for that date from the current temperature. That would work if the Earth’s temperature had increased gradually without too many “ups and downs”, but a quick look at data from NASA - the estimated yearly (January-December) temperature since 1880 (Figure 1<sup>1</sup>) and various “running means” since 1990 (Figure 2<sup>2</sup>) - shows that the Earth’s temperature varies considerably from month-to-month, year-to-year, etc. In addition, different scientific organizations have different values for the years 1880-2014 – see Figure 3 (UK Met Office Hadley Centre – HadCrut4<sup>3</sup>) and Figure 4 (IPCC<sup>4</sup>) and the actual data below.

There was very little total temperature change from about 1880 to 1930, so averaging the temperature over that time period gives the best “starting point”. Since the Earth’s temperature is expected to continue to increase, the expected 2015 temperature provides the best “ending point”. Table 1 gives the temperature increase for several of the many possible ways of measuring how much the Earth has warmed (assuming a 2015 temperature of about .81° C above the 1951-1980 base period – see Figure 5<sup>5</sup> and .62° C above the base line for the HadCRUT4 data<sup>3</sup>). In addition, the IPCC reports a “warming of 0.85 [0.65 to 1.06] °C, over the period 1880 to 2012, when multiple independently produced datasets exist”<sup>4</sup>. So with an expected increase of about .16° C from 2012 through 2015<sup>3</sup>, the IPCC estimate for 2015 becomes 1.01° C. It then seems reasonable to assume that 2015 (or 2016 using the HadCRUT4 data) will be the year in which the temperature increase from pre-industrial times will first exceed 1° C.

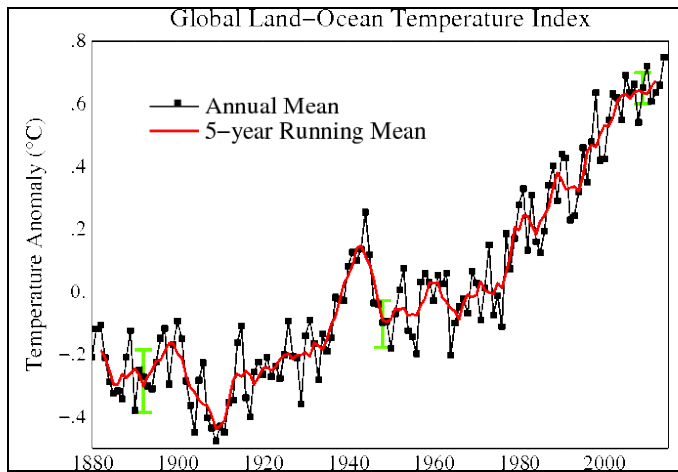


Figure 1 – Global Land-Ocean Temperature Index<sup>1</sup> (NASA)

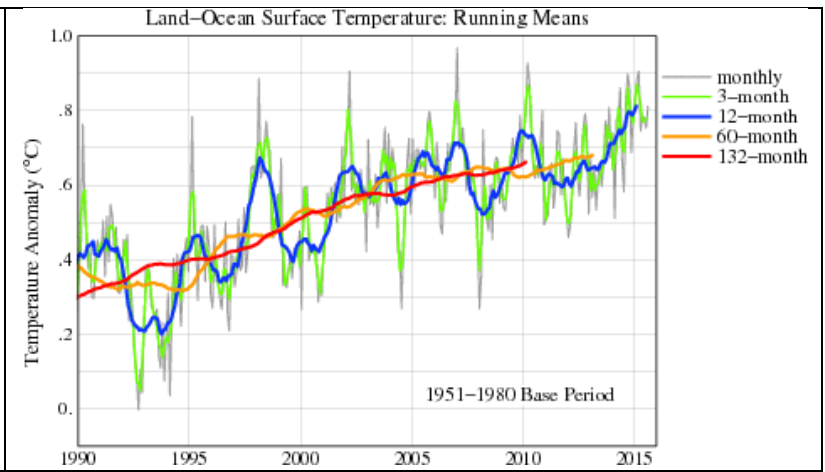


Figure 2 – Land-Ocean Surface Temperature – Running Means<sup>2</sup> (NASA)

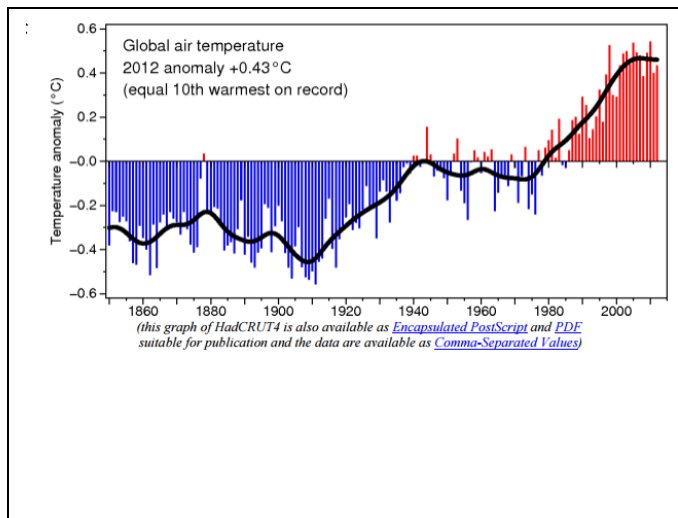


Figure 3 – Global Air Temperature Anomaly<sup>3</sup> (HadCRUT4)

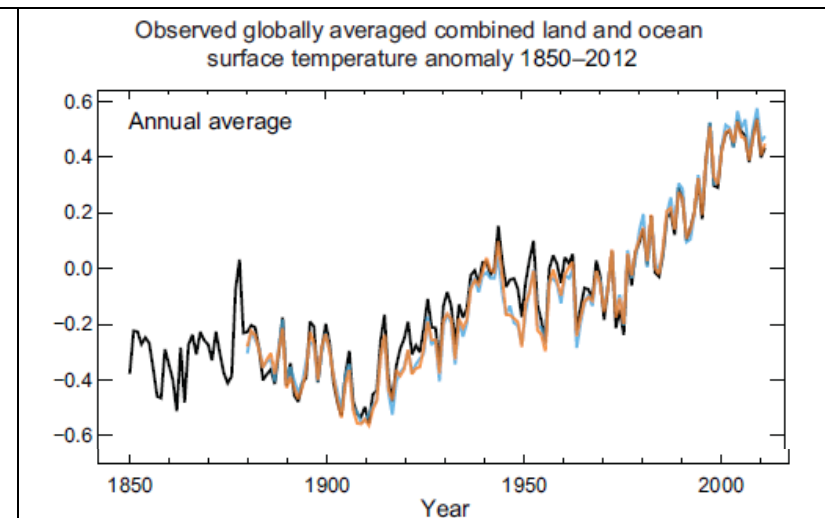


Figure 4 Average Annual Land/Ocean Surface Temperature<sup>4</sup> (IPCC)

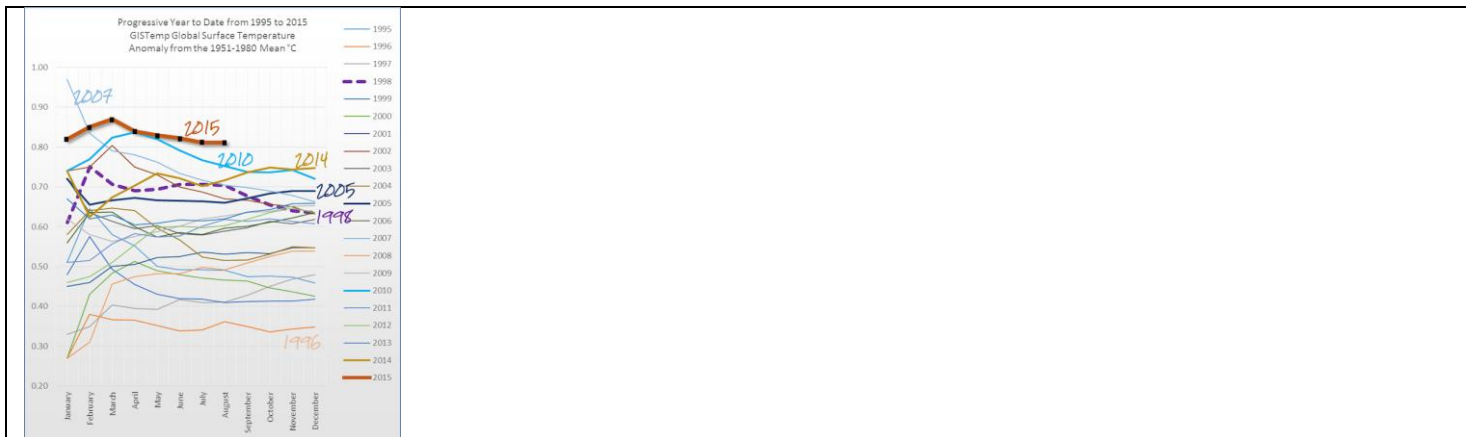


Figure 5 – Progressive Year-To-Date Global Temperatures 1995-2015<sup>5</sup>

#	NASA <sup>6</sup>			HadCRUT4 <sup>3</sup>			Description
	Increase	From	To <sup>6</sup>	Increase	From	To	
1.	1.01	-0.2	.81	.85	-0.23	.62	1880 to 2015
2.	1.29	-0.48	.81	1.16	-0.54	.62	1909 to 2015 (lowest annual anomaly since 1880)
3.	1.05	-0.24	.81	.95	-0.33	.62	Average anomaly 1880-1899 to 2015
4.	1.08	-0.27	.81	.96	-0.34	.62	Average anomaly 1880-1929 to 2015
5.	1.12	-0.31	.81	.97	-0.35	.62	Average anomaly 1900-1929 to 2015

Table 1 – Calculations of the temperature increase since pre-industrial times (degrees C)

References

1.	<a href="http://data.giss.nasa.gov/gistemp/graphs_v3/Fig.A2.gif">http://data.giss.nasa.gov/gistemp/graphs_v3/Fig.A2.gif</a> ( <a href="http://data.giss.nasa.gov/gistemp/graphs_v3/">http://data.giss.nasa.gov/gistemp/graphs_v3/</a> )
2.	<a href="http://www.columbia.edu/~mhs119/Temperature/T_moreFigs/RunningMeans_v4.gif">http://www.columbia.edu/~mhs119/Temperature/T_moreFigs/RunningMeans_v4.gif</a> ( <a href="http://www.columbia.edu/~mhs119/Temperature/T_moreFigs/">http://www.columbia.edu/~mhs119/Temperature/T_moreFigs/</a> )
3.	<a href="http://www.cru.uea.ac.uk/documents/421974/1295957/Info+sheet+%231.pdf/c612fc7e-babb-463c-b5e3-124ac76680c5">http://www.cru.uea.ac.uk/documents/421974/1295957/Info+sheet+%231.pdf/c612fc7e-babb-463c-b5e3-124ac76680c5</a> 2014 estimated anomaly - .563°C. For NASA, the increase from 2014 to 2015 is about .06°C. Applying the same increase to the HadCrut4 data yields an estimated 2015 anomaly of .623°C. 2012 estimated anomaly - .467°C, so the increase through 2015 is an additional .16°C
4.	CLIMATE CHANGE 2013 - The Physical Science Basis (Page 6) ( <a href="http://www.ipcc.ch/report/ar5/wg1/">http://www.ipcc.ch/report/ar5/wg1/</a> )
5.	<a href="http://thinkprogress.org/climate/2015/09/14/3701298/august-2015-record-warmth/">http://thinkprogress.org/climate/2015/09/14/3701298/august-2015-record-warmth/</a>
6.	Global Land-Ocean Temperature Index (C) (Anomaly with Base: 1951-1980) ( <a href="http://data.giss.nasa.gov/gistemp/graphs_v3/Fig.A2.txt">http://data.giss.nasa.gov/gistemp/graphs_v3/Fig.A2.txt</a> )

Temperature Data

**Global Temperature Anomalies**

Year	HadCRUT4		NASA	
	Anomaly	Smoothed	Annual Mean	5-year Mean
1850	-0.376	-0.3		
1851	-0.222	-0.297		
1852	-0.225	-0.297		
1853	-0.27	-0.302		
1854	-0.247	-0.31		
1855	-0.27	-0.323		
1856	-0.36	-0.336		
1857	-0.457	-0.349		
1858	-0.463	-0.36		
1859	-0.284	-0.367		
1860	-0.341	-0.37		
1861	-0.398	-0.368		
1862	-0.508	-0.363		
1863	-0.28	-0.353		
1864	-0.48	-0.34		
1865	-0.269	-0.325		
1866	-0.24	-0.311		
1867	-0.304	-0.3		
1868	-0.22	-0.291		
1869	-0.256	-0.287		
1870	-0.271	-0.285		
1871	-0.324	-0.285		
1872	-0.228	-0.284		
1873	-0.302	-0.281		
1874	-0.371	-0.274		
1875	-0.408	-0.263		
1876	-0.38	-0.249		
1877	-0.07	-0.236		
1878	0.035	-0.228		
1879	-0.229	-0.226		
1880	-0.225	-0.233	-0.21	*
1881	-0.204	-0.246	-0.12	*
1882	-0.212	-0.265	-0.11	-0.19
1883	-0.29	-0.285	-0.21	-0.21
1884	-0.403	-0.305	-0.29	-0.25
1885	-0.385	-0.321	-0.32	-0.3
1886	-0.369	-0.334	-0.32	-0.3
1887	-0.42	-0.344	-0.34	-0.26
1888	-0.314	-0.352	-0.21	-0.27
1889	-0.178	-0.358	-0.12	-0.26
1890	-0.422	-0.363	-0.38	-0.25
1891	-0.342	-0.366	-0.25	-0.26

1892	-0.461	-0.367	-0.27	-0.3
1893	-0.476	-0.364	-0.30	-0.27
1894	-0.411	-0.357	-0.31	-0.25
1895	-0.396	-0.347	-0.23	-0.22
1896	-0.194	-0.337	-0.15	-0.22
1897	-0.214	-0.329	-0.12	-0.19
1898	-0.414	-0.326	-0.29	-0.16
1899	-0.293	-0.33	-0.17	-0.16
1900	-0.201	-0.339	-0.09	-0.2
1901	-0.268	-0.353	-0.15	-0.21
1902	-0.412	-0.37	-0.29	-0.27
1903	-0.481	-0.388	-0.36	-0.31
1904	-0.528	-0.406	-0.45	-0.32
1905	-0.383	-0.423	-0.28	-0.34
1906	-0.293	-0.437	-0.23	-0.36
1907	-0.474	-0.448	-0.40	-0.36
1908	-0.522	-0.454	-0.44	-0.39
1909	-0.537	-0.456	-0.48	-0.44
1910	-0.497	-0.45	-0.43	-0.43
1911	-0.553	-0.439	-0.45	-0.41
1912	-0.448	-0.422	-0.35	-0.35
1913	-0.438	-0.402	-0.35	-0.28
1914	-0.256	-0.382	-0.16	-0.26
1915	-0.163	-0.363	-0.11	-0.27
1916	-0.397	-0.347	-0.34	-0.25
1917	-0.477	-0.331	-0.40	-0.27
1918	-0.342	-0.317	-0.26	-0.3
1919	-0.282	-0.303	-0.22	-0.27
1920	-0.25	-0.291	-0.26	-0.25
1921	-0.192	-0.278	-0.21	-0.24
1922	-0.309	-0.265	-0.27	-0.25
1923	-0.275	-0.254	-0.24	-0.24
1924	-0.3	-0.243	-0.28	-0.22
1925	-0.219	-0.234	-0.20	-0.2
1926	-0.112	-0.224	-0.09	-0.2
1927	-0.213	-0.215	-0.21	-0.21
1928	-0.213	-0.207	-0.21	-0.2
1929	-0.353	-0.198	-0.36	-0.2
1930	-0.141	-0.189	-0.14	-0.19
1931	-0.089	-0.179	-0.09	-0.21
1932	-0.137	-0.167	-0.17	-0.16
1933	-0.274	-0.154	-0.28	-0.17
1934	-0.13	-0.138	-0.13	-0.18
1935	-0.176	-0.12	-0.19	-0.15
1936	-0.145	-0.1	-0.15	-0.1
1937	-0.028	-0.08	-0.02	-0.08
1938	-0.006	-0.059	-0.02	-0.03

1939	-0.056	-0.04	-0.03	0.03
1940	0.017	-0.024	0.08	0.05
1941	0.017	-0.012	0.13	0.08
1942	-0.025	-0.005	0.10	0.14
1943	-0.002	-0.001	0.14	0.15
1944	0.147	-0.003	0.25	0.11
1945	0.033	-0.009	0.12	0.09
1946	-0.069	-0.017	-0.04	0.04
1947	-0.042	-0.028	-0.04	-0.03
1948	-0.037	-0.037	-0.10	-0.09
1949	-0.075	-0.045	-0.09	-0.1
1950	-0.175	-0.051	-0.18	-0.09
1951	-0.049	-0.056	-0.07	-0.05
1952	0.031	-0.06	0.01	-0.06
1953	0.1	-0.063	0.08	-0.05
1954	-0.13	-0.065	-0.12	-0.08
1955	-0.186	-0.064	-0.14	-0.07
1956	-0.264	-0.06	-0.20	-0.08
1957	-0.003	-0.053	0.03	-0.04
1958	0.049	-0.046	0.06	-0.02
1959	0.017	-0.039	0.03	0.03
1960	-0.048	-0.035	-0.03	0.03
1961	0.039	-0.036	0.05	0.03
1962	0.017	-0.042	0.03	-0.02
1963	0.05	-0.05	0.06	-0.03
1964	-0.222	-0.058	-0.20	-0.05
1965	-0.141	-0.065	-0.10	-0.06
1966	-0.072	-0.07	-0.05	-0.09
1967	-0.076	-0.074	-0.02	-0.03
1968	-0.112	-0.075	-0.07	-0.01
1969	0.03	-0.076	0.07	-0.02
1970	-0.028	-0.077	0.03	-0.01
1971	-0.184	-0.08	-0.09	0.03
1972	-0.068	-0.081	0.01	0
1973	0.064	-0.082	0.15	0
1974	-0.211	-0.078	-0.07	-0.01
1975	-0.145	-0.07	-0.01	0.03
1976	-0.238	-0.057	-0.11	0.01
1977	0.046	-0.038	0.19	0.06
1978	-0.062	-0.016	0.07	0.12
1979	0.057	0.006	0.17	0.21
1980	0.093	0.026	0.28	0.2
1981	0.14	0.044	0.33	0.24
1982	0.011	0.058	0.13	0.24
1983	0.19	0.069	0.31	0.21
1984	-0.015	0.081	0.16	0.18
1985	-0.029	0.094	0.13	0.22

1986	0.046	0.11	0.19	0.24
1987	0.187	0.126	0.34	0.27
1988	0.2	0.144	0.40	0.33
1989	0.12	0.162	0.29	0.38
1990	0.294	0.178	0.44	0.36
1991	0.255	0.194	0.43	0.33
1992	0.104	0.21	0.23	0.33
1993	0.145	0.228	0.24	0.34
1994	0.206	0.249	0.32	0.32
1995	0.323	0.273	0.46	0.37
1996	0.181	0.298	0.35	0.45
1997	0.39	0.325	0.48	0.47
1998	0.535	0.351	0.63	0.46
1999	0.307	0.375	0.42	0.5
2000	0.294	0.398	0.42	0.53
2001	0.439	0.419	0.55	0.53
2002	0.495	0.438	0.63	0.55
2003	0.507	0.453	0.62	0.61
2004	0.448	0.465	0.55	0.62
2005	0.543	0.474	0.69	0.63
2006	0.505	0.479	0.64	0.62
2007	0.493	0.482	0.66	0.64
2008	0.394	0.483	0.54	0.64
2009	0.504	0.485	0.65	0.64
2010	0.555	0.486	0.72	0.63
2011	0.421	0.488	0.61	0.65
2012	0.467	0.489	0.64	0.67
2013	0.492	0.491	0.66	*
2014	0.563	0.493	0.75	*
2015	0.623 <sup>+</sup>		0.81 <sup>#</sup>	*

<sup>+</sup> Calculated based on NASA data and “Progressive Year-To-Date Global Temperatures 1995-2015<sup>5</sup>”

<sup>#</sup> Based on “Progressive Year-To-Date Global Temperatures 1995-2015<sup>5</sup>”

HadCRUT4 <http://www.cru.uea.ac.uk/documents/421974/1295957/Info+sheet+%231.pdf/c612fc7e-babb-463c-b5e3-124ac76680c5>  
(link on the above page)

NASA [http://data.giss.nasa.gov/gistemp/graphs\\_v3/fig.A2.txt](http://data.giss.nasa.gov/gistemp/graphs_v3/fig.A2.txt)