Greenhouse Warming Scorecard

(Updated 4/2/2006)

The tables below provide a comparison of model predictions with actual observations and provide a yes-no-undetermined score of whether the models are successful or not. Later in listings there are pro and con discussions of various topics and these are not scored.

Type of prediction	1900-2000 surface temperature trend
Model prediction	1.1 to 3.3 C warming if all greenhouse gases are included (IPCC 2001)
Actual measurements	Surface temperature warming of 0.6 C
Comments	Predicted warming is 2 to 5 times greater than observed warming. Lindzen says it is 4 times too large. Alternative and additional sources of warming include the sun, UHI and land use changes, soot on snow, and other reasons. More on land use changes here. More on the warm bias in surface observations here.
Score	0-1-0 Scoring is won-lost-tie system. A win means models and observations reasonably agree. A loss means significant disagreement. A tie means the models or observations give contradictory results.

Type of prediction	1979-2005 mid-tropospheric warming
Model prediction	About 0.15 to 0.58 C warming per decade (IPCC 2001)

Actual measurements	Between 0.1 and 0.14 C/decade. "In all cases these trends are positive. The increase in the UAH time series is 0.12 C/decade (0.22 F/decade), 0.14 C/decade (0.24 F/decade) for the RSS analysis and 0.10 C/decade (0.17 F/decade) for the University of Washington. Trends in UAH, RSS and UW data are less than the trend in global surface temperatures, which increased at a rate near 0.18 C/decade (0.32 F/decade) during the same 27 year period."
Comments	The predicted warming is less than the model warming.
Score	0-2-0

Type of prediction	Surface and mid-tropospheric warming, 1979-2005
Model prediction	Mid-tropospheric warming should be 50-100% larger than surface warming.
Actual measurements	Surface warming is 0.18 C/decade compared to mid-tropospheric warming of 0.12 C/decade, opposite of what theory predicts.
Comments	A discussion can be found here. And here. And here.
Score	0-3-0

Type of prediction	Arctic warming
Model prediction	1.0 to 3.0 C/decade warming (IPCC 1995)
Actual measurements	Temperatures now are nearly the same as they were in 1940, consistent with large oscillations rather than a trend.
Comments	The arctic is probably warming due to ocean currents rather than greenhouse gases. A trend outside normal variations has not yet happened.
Score	0-4-0

Type of prediction	Animals and plants are migrating towards the poles (Parmesan and Yohe, 2003)
Model prediction	Study claims it provides evidence that climate models are correct.
Actual measurements	Actually the migration rates are consistent with a warming of 0.025 C/decade which is much smaller than models predict.
Comments	These results actually undermine the model predictions and may be an indication that the surface temperature record is overestimating the warming.
Score	0-5-0

Type of prediction	Medieval Warm Period (ca. 1000-1200 AD)
Model prediction	The state of the art GFDL climate model claims the Medieval Warm Period is physically impossible (Stouffer et al., 1994)
Actual measurements	The MWP exists according to borehole temperature measurements at 6000 locations (Huang et al., 1997).
Comments	More discussion can be at http://www.climateaudit.org/index.php?cat=8
Score	0-6-0

Type of prediction	Diurnal temperature range
Model prediction	Originally no change was predicted in the models, but some later models may have a change in DTR.
Actual measurements	Decreasing.
Comments	More discussion here and here.
Score	0-6-1

Type of prediction	Annual cycle of temperature.
Model prediction	0.5 to 1.1 C decrease predicted to have occurred in 20^{th} century.
Actual measurements	0.1 C decrease observed (Mann and Park, 1996).
Comments	Model prediction is 5 to 10 times too large.
Score	0-7-1

Type of prediction	Phase of annual cycle
Model prediction	Predicted change of -1.7 days in 20^{th} century.
Actual measurements	+0.8 days increase (Mann and Park, 1997).
Comments	Model predictions have wrong sign.
Score	0-8-1

Type of prediction	Stratospheric cooling.
Model prediction	Several degrees per decade predicted (IPCC 1995)
Actual measurements	Some cooling to 1995 and no trend since then.
Comments	Model predictions are too large.
Score	0-9-1

Type of prediction	Temperature lapse rate in tropics
Model prediction	Decreasing.
Actual measurements	Appears to have increased.

Comments	There is probably a problem with the convection parameterizations in the model. More discussion here.
Score	0-10-1

Type of prediction	Temperature lapse rate in the arctic.
Model prediction	Increasing.
Actual measurements	No change observed.
Comments	There is probably a problem with the convection parameterizations in the model. More discussion here.
Score	0-11-1

Type of prediction	Hurricane frequency.
Model prediction	More (Houghton et al., 1988 and the popular press)
Actual measurements	No clear trend. Possible small decrease since 1940 (Landsea et al., 1996)
Comments	Climate modelers tend to say there is an increase. Hurricane experts say the numbers oscillate of many years and there is no evidence for a trend.
Score	0-11-2

Type of prediction	Hurricane intensity
Model prediction	Greater (Houghton et al., 1988 and the popular press).
Actual measurements	No trend in 20th century.
Comments	Models not confirmed so far.
Score	0-12-2

Type of prediction	Sea levels
Model prediction	Rising at 0.5 cm/yr (IPCC 1995)
Actual measurements	Rising at 0.18 Cm/yr (1993-present).
Comments	Models not confirmed. More discussion here, and here.
Score	0-13-2

Type of prediction	Extreme weather events.
Model prediction	More
Actual measurements	Only one scientific study found an increase and that was for extreme precipitation events in the US (Karl et al., 1993). All other studies show no trend or decreases.
Comments	Discussion here and here. If you sift through enough climate parameters at enough locations, one of them is bound to show a significant trend (data mining).
Score	0-14-2

Type of prediction	Northern Hemisphere snow cover.
Model prediction	Decreasing.
Actual measurements	No clear trend.
Comments	More discussion here and here.
Score	0-15-2

Type of prediction	Southern Hemisphere snow cover.
Model prediction	Decreasing.

Actual measurements	Increasing according to Cavaleri et al. (1997) for 1978-1996, but no trend according to Johannessen et al. (1995).
Comments	More discussion here.
Score	0-16-2

Type of prediction	Southern Hemisphere sea ice cover using European whaling observations.
Model prediction	Decreasing.
Actual measurements	Decreased by 25% from 1958 to 1970 when European whaling ships were not in region (De La Mare, 1997). Japanese whaling ships were in this region between 1946 and 1965 and their observations do not confirm the European whaling observations (Mierzejewska et al. (1997).
Comments	Evidence is contradictory.
Score	0-16-3

Type of prediction	Arctic sea ice thickness and extent.
Model prediction	Models predict thinning (Rothcock et al., 1999).
Actual measurements	Probably thinning and decreasing in area, but perhaps from ocean currents or soot.
Comments	Discussion here.
Score	1-16-3

Type of prediction	Mountain glaciers.
Model prediction	Receding worldwide.

Actual measurements	Receding worldwide since 1750, but apparently not back to their locations in the MWP. As examples, the Aletsch and Grindelwald glaciers (Switzerland) were much smaller than today between 800 and 1000 AD. In 1588, the Grindelwald glacier broke through its end moraine and it is still larger than it was in 1588 and earlier years. In Iceland today, the outlet glaciers of Drangajökull and Vatnajökull are far advanced over what they were in the Middle Ages and farms remain buried beneath the ice.
Comments	Glacier recession started before greenhouse gases significantly increased. The sun has gotten steadily more active since 1700 and provides a better explanation for the glacial recession. More discussion here. Also see this discussion.
Score	1-17-3

Type of prediction	Kilimanjaro glacier
Model prediction	Claimed to be receding due to greenhouse gas warming.
Actual measurements	No temperature trend at nearby locations. Recession appears to be caused by precipitation decreases and nearby deforestation.
Comments	More discussion here and here.
Score	1-18-3

Type of prediction	Montana glaciers
Model prediction	Claimed to be receding due to greenhouse gas warming.
Actual measurements	No temperature trend at nearby locations. Recession appears to be caused by precipitation decreases.
Comments	More discussion here .
Score	1-19-3

Type of prediction	Secular increase in anthropogenic aerosols to account for global warming being less than predicted.
Model prediction	Modeling efforts indicate the trend in aerosols should be largest in central Europe (Charlson et al., 1991).
Actual measurements	Actual measurements at Davos, Switzerland from 1909 to 1979 showed no trend in aerosols where climate models claim a maximum trend. Ref. Hoyt, D. V. and C. Frohlich, 1983. Atmospheric transmission at Davos, Switzerland, 1909-1979. Climatic Change, 5, 61-72.
Comments	Models do not agree with measurements at Davos or in nearby Belgium and Ireland.
Score	1-20-3

Type of prediction	Cloud cover.
Model prediction	Some models predict and increase and others predict and a decrease, but the increases or decreases should be monotonic with changes in greenhouse gases.
Actual measurements	Between 1950 and 1985 global dimming occurred consistent with cloud cover increases. Between 1985 and now, cloud cover has decreased and global brightening is occurring.
Comments	Cloud cover variations are larger than models predict and have no correlation with greenhouse gas concentrations. More discussion here, here, and here. Michaels summarizes it as follows: “Enhanced greenhouse effect during industrial era: 2.4 W/m2. According to page 66 of the 2001 compendium of the United Nations’ Intergovernmental Panel on Climate change (IPCC), about a quarter of this amount, or 0.6 W/m2, has occurred since the mid-1980s. Change in solar radiation absorbed by the earth from

	2000 to 2004, estimated from low-orbiting satellite data, reported by Wielicki et al.: 2.06 W/m2. Change from 1983 to 2001 in solar radiation absorbed by the earth, estimated at the surface by satellites, reported by Pinker et al.: 2.7 W/m2. Change from 1985 to 2000 solar radiation absorbed at the surface, as measured at the surface, reported by Wild et al.: 4.4 W/m2. If we average the results of Pinker et al. and Wild et al., we get 3.55 W/m2 for the period 1985 to 2000. To this we add 2.06 W/m2 from 2000 to 2004 and get 5.61 W/m2. If we divide this by 0.6 W/m2 (the total change in greenhouse forcing from 1985 to 2004, we get 9.35. The added forcing from increased solar radiation reaching the earth's surface has contributed nearly 10 times as much energy as greenhouse changes! When compared to the overall greenhouse forcing since pre-industrial times, it's four times larger."
Score	1-21-3

Type of prediction	Precipitation.
Model prediction	Most models predict increases.
Actual measurements	Precipitation seems to be oscillating since 1915.
Comments	Insufficient data to test models properly. Variability of precipitation is discussed here. Global trends are discussed here and here.
Score	1-21-4

Type of prediction	El Nino frequency

Model prediction	Fewer (Knutson and Manabe, 1995). More (Clement et al., 1996).
Actual measurements	1940-1979; 13 events or 0.33/yr. 1979-2005, 7 events or 0.27/yr. No secular trend evident.
Comments	More discussion here.
Score	1-22-4

Type of prediction	Coral bleaching
Model prediction	More predicted as warm water episodes above 29 C become more frequent.
Actual measurements	1940-1979: 15 bleaching events or 0.38/yr. 1979-1997: 6 events or 0.33/yr. No clear trend.
Comments	More discussion here.
Score	1-23-4

Type of prediction	Ocean warming
Model prediction	Warming caused by direct heating of thermal radiation at 15 microns.
Actual measurements	Warming of about 0.06 C over 50 years. More here.

Comment	The absorption coefficient for liquid water as a function of wavelength is given at http://www.lsbu.ac.uk/water/vibrat.html (see the figure near the end). Thermal infrared in the Earth's atmosphere is around 10 to 20 microns where the absorption coefficient (A) is about 1000 cm-1. The transmission in liquid water (T) equals exp(-A*L) where L is the depth of penetration. For the case where 1/e or 27% of the incident photons remain unabsorbed, with A=1000 cm-1, the L= 1/1000 cm = 1/100 mm. 98% of the incident photons will be absorbed within 3 times this distance. So one can see from the figure, than practically no infrared photons penetrate beyond 3/100 mm. When I said all the photons are absorbed in the top millimeter of the water, I was being very generous. A more precise estimate of A is 5000 cm-1 at 15 microns where carbon dioxide is emitting radiation, so even 0.03 mm is extremely generous. Since the liquid water is such an effective absorber, it is a very effective emitter as well. The water will not heat up, it will just redirect the energy back up to the atmosphere much like a mirror. It is worth mentioning for A = 5000 cm-1 at 15 microns, the implied water emissivity is 0.9998 implying that of the incident radiation only 0.02% of it will be absorbed. The emitted radiation will closely follow a blackbody emission curve whereas the incident flux from carbon dioxide is confined to a band centered at 15 microns. The implication of this is that much of the radiation emitted will escape directly to space through the IR windows, so it is a negative feedback. The initially absorbed energy cannot be transferred to the ocean depths by conduction (too slow), by convection (too small an absorption layer), or by radiation (too opaque). It must escape by the fastest way possible meaning upwards radiation away from the water. I don't see why anyone is having problems understanding basic physics. The only way to explain the ocean heating in depth is for

	the solar radiation to change and decreasing clouds, as measured by ISCCP, indicate increasing solar radiation is occurring right where the ocean heating is reported to be occurring. The Willis paper does not even mention the ISCCP data that has a similar geographic distribution to the water warming. Simply put, where clouds decrease in amount, the water warms. It has nothing to do with carbon dioxide. A handy plot of the ISCCP results can be found as Figure 3 at http://www.worldclimatereport.com/index.php/2006/01/11/jumping-to-conclusions-frogs-global-warming-and-nature/ Clouds have large natural variations going up and down entirely independent of any greenhouse effect. The climate models do not predict these variations and apparently Willis and others are unaware of these variations.
Score	1-24-4

Type of prediction	Total feedbacks
Model prediction	Positive and increasing non-feedback warming of 1.2 C to between 1.5 and 4.5 C.
Actual measurements	Negative.
Comment	Douglass and Knox find a negative climate feedback. Karner, O., 2002: On non-stationarity and anti-persistency in global temperature series. J. Geophys. Res. 107, D20. (See http://www.aai.ee/~olavi/2001JD002024u.pdf). Karner states: “The revealed antipersistence in the lower tropospheric temperature increments does not support the science of global warming developed by IPCC [1996]. Negative long-range correlation of the increments during last 22 years means that negative feedback has been dominating in the Earth climate system during that period. The result is opposite to suggestion of Mitchell [1989] about domination of a

positive cumulative feedback after a forced temperature change. Dominating negative feedback also shows that the period for CO2 induced climate change has not started during the last 22 years. Increasing concentration of greenhouse gases in the Earth atmosphere appeared to produce too weak forcing in order to dominate in the Earth climate system."

Karner finds a Hurst exponent of 0.27 +/-0.04 for tropospheric temperatures. From an online primer by Ian Kaplan <http://www.bearcave.com/misl/misl_tech/wavelets/hurst/>, the following meaning is giving to this number:

"The values of the Hurst exponent range between 0 and 1. A value of 0.5 indicates a true random walk (a Brownian time series). In a random walk there is no correlation between any element and a future element. A Hurst exponent value H, 0.5 < H < 1 indicates "persistent behavior" (e.g., a positive autocorrelation). If there is an increase from time step ti-1 to ti there will probably be an increase from ti to ti+1. The same is true of decreases, where a decrease will tend to follow a decrease. A Hurst exponent value 0 < H < 0.5 will exist for a time series with "anti-persistent behavior" (or negative autocorrelation). Here an increase will tend to be followed by a decrease. Or a decrease will be followed by an increase. This behavior is sometimes called "mean reversion"."

Key conclusions from these studies:

1. The climate system has a net negative feedback, opposite to what the claim of a positive feedback made by the IPCC.

2. Consequently, "increasing concentration of greenhouse gases in the Earth atmosphere appeared to produce too weak forcing in order to dominate in the Earth climate system."

Score	1-25-4

Type of prediction	Water vapor feedback
Model prediction	Positive and totally controlled thermodynamically via the Clausius-Clapeyron equation
Actual measurements	Measurements are contradictory. It appears that dynamics dominates the amount of water vapor rather than thermodynamics.
Comment	A good summary is found here. “The final result of Minschwaner and Dessler’s efforts is that it is likely that the actual strength of the positive water vapor feedback, at least in the tropics, is significantly less than is inherent in current GCMs.”
Score	1-26-4

Type of prediction	Amplitude of warming for a doubling of carbon dioxide using temperature and CO2 concentrations for the last 470 million years
Model prediction	IPCC predicts a warming of 1.5 to 4.5 C per doubling.
Actual measurements	Measurements give a 1.0 C warming per doubling.
Comment	Recently Berner et al looked at carbon dioxide and temperature variations over the last 470 million years. Willis Eschenbach looked at this paper and writes: "Assuming Berner’s figures are correct, then both CO2 and cosmic rays affect the temperature over the last 450 million years. The correlation with log(CO2) alone is R^2 = 0.63. Using log(cosmic rays) alone is R^2 = 0.42. (The log of both CO2 and cosmic rays give a much better fit to temperature than the data itself.)

	Using a linear regression with both gives R^2 = 0.79. A very interesting finding from this analysis is that the resulting climate sensitivity is 1.0 C +/- 0.2 (2 std. dev.) per doubling of CO2." So experimentally, the measured variations are within the range I calculate and are outside the range that the IPCC assumes. So I think I have a case. In addition, if the 1.0 C number is correct, then 0.4 C of the warming in the twentieth century can be attributed to carbon dioxide with the rest due to other factors. So everything falls in to place and there is no need to come up with excuses why the IPCC predicted warming is hidden. Finally, if one has a further 0.6 C warming as carbon dioxide doubles (if it actually can do so), then it would not seem to be much of a problem, certainly not catastrophic. Reference: Berner et al., 2004. Geo. Soc. Am., Vol. 14., No. 3, pp. 4-10.
Score	1-27-4

In the following tables, various claims are examined concerning measurements and not comparisons between models and measurements. These results are not scored.

Claim	Urban heat islands do have a significant effect on observed temperature trends (e.g., Peterson, 1999). Thomas C. Peterson (2003). "Assessment of Urban Versus Rural In Situ Surface Temperatures in the Contiguous United States: No Difference Found". Journal of Climate 16: 2941–2959.

Counter-claim	Urban heat islands are not accounted for properly in calculating global temperature trends (e.g., McKitrick and Michaels, 2003). McKitrick, R. and Michaels, P.J. 2004. A test of corrections for extraneous signals in gridded surface temperature data. Climate Research 26: 159-173.
Pro discussion taken from wikipedia	Because some parts of some cities may be several degrees hotter than their surroundings, a difference double or triple the warming observed over the historical temperature record, there is a risk that the effects of urban sprawl might be misinterpreted as an increase in global temperature. However, the fact that the UHI is so large is, paradoxically, evidence that it is largely absent from the record, otherwise warming would be shown as much larger in the record. The 'heat island' warming does unquestionably affect cities and the people who live in them, but it is not at all clear that it biases trends in historical temperature record: for example, urban and rural trends are very similar. The IPCC says: However, over the Northern Hemisphere land areas where urban heat islands are most apparent, both the trends of lower-tropospheric temperature and surface air temperature show no significant differences. In fact, the lower-tropospheric temperatures warm at a slightly greater rate over North America (about 0.28°C/decade using satellite data) than do the surface temperatures (0.27°C/decade), although again the difference is not statistically significant. Note that not all cities show a warming relative to their rural surroundings. For example, Hansen et al. (JGR, 2001) adjusted trends in urban stations around the world to match rural stations in their regions, in an effort to homogenise the temperature record. Of these adjustments, 42% warmed the urban trends: which is to say that in 42% of cases, the cities were getting cooler relative to their surroundings rather than warmer. One reason is that urban areas are heterogeneous, and weather stations are often sited in "cool islands" - parks,

for example - within urban areas.

The Intergovernmental Panel on Climate Change, which has issued several influential reports on climate trends, says that the effects of urban heat islands on the recorded temperature "do not exceed about 0.05°C over the period 1900 to 1990." Note that this is a maximum: it does not exclude zero influence. This statement rests on various sources, contributing reasons being:

land, sea, and borehole records are in reasonable agreement over the last century. (Much more heat has gone into the earth and the ocean depths than remains in the wispy atmosphere, and the ocean and borehole records have not been questioned.).

the trends in urban stations for 1951 to 1989 (0.10°C/decade) are not greatly more than those for all land stations (0.09°C/decade).

simlarly the rural trend is 0.70°C/century from 1880 to 1998, which is actually larger than the full station trend (0.65°C/century).(Peterson et al., GRL, 1999)

the differences in trend between rural and all stations are also virtually unaffected by elimination of areas of largest temperature change, like Siberia, because such areas are well represented in both sets of stations.

Over the Northern Hemisphere land areas where urban heat islands are most apparent the trends of lower-tropospheric temperature and surface air temperature show no significant differences. In fact, the lower-tropospheric temperatures warm at a slightly greater rate over North America (about 0.28C/decade using satellite data) than do the surface temperatures (0.27C/decade). [14]

A 2003 paper ("Assessment of urban versus rural in situ surface temperatures in the contiguous United States: No difference found"; J climate; Peterson; 2003) indicates that the effects of the urban heat island may have been overstated, finding that "Contrary to generally accepted wisdom, no statistically significant impact of urbanization could be found in annual temperatures." This was done by using satellite-based night-light detection of urban areas, and more thorough

	homogenisation of the time series (with corrections, for example, for the tendency of surrounding rural stations to be slightly higher, and thus cooler, than urban areas). As the paper says, if its conclusion is accepted, then it is necessary to "unravel the mystery of how a global temperature time series created partly from urban in situ stations could show no contamination from urban warming." The main conclusion is that micro- and local-scale impacts dominate the meso-scale impact of the urban heat island: many sections of towns may be warmer than rural sites, but meteorological observations are likely to be made in park "cool islands." A study by David Parker published in Nature in November 2004 attempts to test the urban heat island theory, by comparing temperature readings taken on calm nights with those taken on windy nights. If the urban heat island theory is correct then instruments should have recorded a bigger temperature rise for calm nights than for windy ones, because wind blows excess heat away from cities and away from the measuring instruments. There was no difference between the calm and windy nights, and the author says: we show that, globally, temperatures over land have risen as much on windy nights as on calm nights, indicating that the observed overall warming is not a consequence of urban development [15] [16]
Continued	simlarly the rural trend is 0.70°C/century from 1880 to 1998, which is actually larger than the full station trend (0.65°C/century).(Peterson et al., GRL, 1999) the differences in trend between rural and all stations are also virtually unaffected by elimination of areas of largest temperature change, like Siberia, because such areas are well represented in both sets of stations. Over the Northern Hemisphere land areas where urban heat islands are most apparent the trends of lower-tropospheric temperature and surface air temperature show no significant differences. In fact, the lower-tropospheric temperatures warm at a slightly greater rate over North America (about 0.28°C/decade using satellite data) than do the surface temperatures (0.27°C/decade).

A 2003 paper ("Assessment of urban versus rural in situ surface temperatures in the contiguous United States: No difference found"; J climate; Peterson; 2003) indicates that the effects of the urban heat island may have been overstated, finding that "Contrary to generally accepted wisdom, no statistically significant impact of urbanization could be found in annual temperatures." This was done by using satellite-based night-light detection of urban areas, and more thorough homogenization of the time series (with corrections, for example, for the tendency of surrounding rural stations to be slightly higher, and thus cooler, than urban areas). As the paper says, if its conclusion is accepted, then it is necessary to "unravel the mystery of how a global temperature time series created partly from urban in situ stations could show no contamination from urban warming." The main conclusion is that micro- and local-scale impacts dominate the meso-scale impact of the urban heat island: many sections of towns may be warmer than rural sites, but meteorological observations are likely to be made in park "cool islands."

A study by David Parker published in Nature in November 2004 attempts to test the urban heat island theory, by comparing temperature readings taken on calm nights with those taken on windy nights. If the urban heat island theory is correct then instruments should have recorded a bigger temperature rise for calm nights than for windy ones, because wind blows excess heat away from cities and away from the measuring instruments. There was no difference between the calm and windy nights, and the author says: we show that, globally, temperatures over land have risen as much on windy nights as on calm nights, indicating that the observed overall warming is not a consequence of urban development.

Con discussion	Gonzalez et al find an urban heat island of as much as 3 C in San Juan, Puerto Rico and state "a recent climatological analysis of the surface temperature of the city has revealed that the local temperature has been increasing over the neighboring vegetated areas at a rate of 0.06 C per year for the past 30 years." De Laat and Maurellis state "the 'real' global mean surface temperature trend is very likely to be considerably smaller than the temperature trend in the CRU data." Oke finds urban heat islands of 2 to 2.5 C in towns with populations of 1000 people. Hinkel et al found that Pt. Barrow is 2.2 C warmer than the surrounding countryside in winter and its population is 4600 people. The formula for this town in winter would be 1.85*log (pop). It also corresponds to about 0.22 C/decade warming from 1900 to 2000. Streuker finds that "over the course of 12 years, between 1987 and 1999, the mean nighttime surface temperature heat island of Houston increased 0.82 + 0.10 C". Bottyan et al find that in Debrechen, Hungary, with a population of 220,000, has "the strongest developments of UHI occurring in the warmer and colder periods were 5.8 C and 4.9 C respectively." Bohm finds in Vienna that suburban areas had an excess warming of 0.11 to 0.21 C compared to rural areas over 45 years or 0.025 C /decade to 0.047 C/decade. In the urban center there was no warming, but in areas with intensive urban development there was a 0.6 C warming or 0.13 C/ decade. Looking at Shanghai, Chen et al a 1 C greater warming in the city compared to the countryside for 1977 to 1997 or 0.5 C/ decade. They conclude "the main factor causing the intensity

of the heat island in Shanghai is associated with the increasing energy consumption due to economic development."

Zhou et also looked at Chinese data and "estimated warming of mean surface temperature of 0.05 C per decade attributable to urbanization," which they say "is much larger than previous estimates for other periods and locations, including the estimate of 0.027 C/decade for the continental U.S. (Kalnay and Cai, 2003)." They qualify it by saying the numbers apply to winter and China is rapidly developing.

In Seoul, Korea, Chung et al find the change of annual mean daily mean temperature at Seoul was an increase of 0.55 C, or 0.275 C per decade (indicative of an urban-induced warming of 0.2 C per decade in addition to the regional background warming of 0.075 C per decade).

In Mexico, Jáuregui finds the average trend for the seven large cities was 0.57 C/decade, while the average trend for the seven mid-sized cities was 0.37 C/decade, so large cities have at least a 0.2 C/decade spurious warming due to urban effects.

Frauenfeld et al. report that over the period 1958-2000, "time series based on aggregating all station data on the Tibetan Plateau show a statistically significant positive trend of 0.16 C/decade," as has also been reported by Liu and Chen (2000). However, they report that "no trends are evident in the ERA-40 data [i.e., the European Centre for Medium-Range Weather Forecasts (ECMWF) re-analysis] for the plateau as a whole." Land use changes and urban heat islands seem to be causing a 0.16 C/decade warming here where the surface thermometers are placed.

The above articles give 13 cases where the UHI warming per decade is reported. The numbers in increasing order are 0.00, 0.025, 0.027, 0.047, 0.050, 0.060, 0.13, 0.16, 0.20, 0.20, 0.22, 0.50, and 0.82. The mean value is 0.187 C/decade. The medium value is 0.13 C/decade. The two high values of 0.50

and 0.82 C/decade for Shanghai and Houston seem like outliers. Removing them gives a mean warming of 0.10 C/decade and a median value of 0.06 C/decade.

Bottom line: Urban heat trends are significant and can contribute significantly to the reported global warming of 0.06 C/decade. In fact, it could very well explain all the warming.

References:

Bohm, R. 1998. Urban bias in temperature time series - A case study for the city of Vienna, Austria. Climatic Change, 38, 113-128.

Bottyan, Z., Kircsi, A., Szeged, S. and Unger, J. 2005. The relationship between built-up areas and the spatial development of the mean maximum urban heat island in Debrecen, Hungary. International Journal of Climatology, 25, 405-418.

Chen, L., Zhu, W., Zhou, X. and Zhou, Z. 2003. Characteristics of the heat island effect in Shanghai and its possible mechanism. Advances in Atmospheric Sciences, 20, 991-1001.

Chung, U., Choi, J. and Yun, J.I. 2004. Urbanization effect on the observed change in mean monthly temperatures between 1951-1980 and 1971-2000. Climatic Change, 66, 127-136.

De Laat, A.T.J. and Maurellis, A.N. 2004. Industrial CO2 emissions as a proxy for anthropogenic influence on lower tropospheric temperature trends. Geophysical Research Letters, 31,1029.

Frauenfeld, O.W., Zhang, T. and Serreze, M.C. 2005. Climate change and variability using European Centre for Medium-Range Weather Forecasts re-analysis (ERA-40) temperatures on the Tibetan Plateau. Journal of Geophysical Research, 110, 1029.

Gonzalez, J.E., Luvall, J.C., Rickman, D., Comarazamy, D., Picon, A., Harmsen, E., Parsiani, H., Vasquez, R.E., Ramirez, N., Williams, R. and Waide, R.W. 2005. Urban heat islands developing in coastal tropical cities. EOS, Transactions, American Geophysical Union, 86, 397, 403.

Hinkel, K.M., Nelson, F.E., Klene, A.E. and Bell, J.H. 2003. The urban heat island in winter at Barrow, Alaska. International Journal of Climatology, 23, 1889-1905.

Jáuregui, E. 2005. Possible impact of urbanization on the thermal climate of some large cities in Mexico. Atmosfera,18, 249-252.

Liu, X. and Chen, B. 2000. Climatic warming in the Tibetan Plateau during recent decades. International Journal of Climatology, 20, 1729-1742.

Oke, T.R. 1973. City size and the urban heat island. Atmospheric Environment, 7, 769-779.

Streutker, D.R. 2003. Satellite-measured growth of the urban heat island of Houston, Texas. Remote Sensing of Environment, 85, 282-289.

Zhou, L., Dickinson, R.E., Tian, Y., Fang, J., Li, Q., Kaufmann, R.K., Tucker, C.J. and Myneni, R.B. 2004. Evidence for a significant urbanization effect on climate in China. Proceedings of the National Academy of Sciences, 101, 9540-9544.

Continued	In Seoul, Korea, Chung et al find the change of annual mean daily mean temperature at Seoul was an increase of 0.55 C, or 0.275 C per decade (indicative of an urban-induced warming of 0.2 C per decade in addition to the regional background warming of 0.075 C per decade). In Mexico, Jáuregui finds the average trend for the seven large cities was 0.57 C/decade, while the average trend for the seven mid-sized cities was 0.37 C/decade, so large cities have at least a 0.2 C/decade spurious warming due to urban effects. Frauenfeld et al. report that over the period 1958-2000, "time series based on aggregating all station data on the Tibetan Plateau show a statistically significant positive trend of 0.16 C/decade," as has also been reported by Liu and Chen (2000). However, they report that "no trends are evident in the ERA-40 data [i.e., the European Centre for Medium-Range Weather Forecasts (ECMWF) re-analysis] for the plateau as a whole." Land use changes and urban heat islands seem to be causing a 0.16 C/decade warming here where the surface thermometers are placed. The above articles give 13 cases where the UHI warming per decade is reported. The numbers in increasing order are 0.00, 0.025, 0.027, 0.047, 0.050, 0.060, 0.13, 0.16, 0.20, 0.20, 0.22, 0.50, and 0.82. The mean value is 0.187 C/decade. The medium value is 0.13 C/decade. The two high values of 0.50 and 0.82 C/decade for Shanghai and Houston seem like outliers. Removing them gives a mean warming of 0.10 C/decade and a median value of 0.06 C/decade. Bottom line: Urban heat trends are significant and can contribute significantly to the reported global warming of 0.06 C/decade. In fact, it could very well explain all the warming. References: Bohm, R. 1998. Urban bias in temperature time series - A

case study for the city of Vienna, Austria. Climatic Change, 38, 113-128.

Bottyan, Z., Kircsi, A., Szeged, S. and Unger, J. 2005. The relationship between built-up areas and the spatial development of the mean maximum urban heat island in Debrecen, Hungary. International Journal of Climatology, 25, 405-418.

Chen, L., Zhu, W., Zhou, X. and Zhou, Z. 2003. Characteristics of the heat island effect in Shanghai and its possible mechanism. Advances in Atmospheric Sciences, 20, 991-1001.

Chung, U., Choi, J. and Yun, J.I. 2004. Urbanization effect on the observed change in mean monthly temperatures between 1951-1980 and 1971-2000. Climatic Change, 66, 127-136.

De Laat, A.T.J. and Maurellis, A.N. 2004. Industrial CO2 emissions as a proxy for anthropogenic influence on lower tropospheric temperature trends. Geophysical Research Letters, 31,1029.

Frauenfeld, O.W., Zhang, T. and Serreze, M.C. 2005. Climate change and variability using European Centre for Medium-Range Weather Forecasts re-analysis (ERA-40) temperatures on the Tibetan Plateau. Journal of Geophysical Research, 110, 1029.

Gonzalez, J.E., Luvall, J.C., Rickman, D., Comarazamy, D., Picon, A., Harmsen, E., Parsiani, H., Vasquez, R.E., Ramirez, N., Williams, R. and Waide, R.W. 2005. Urban heat islands developing in coastal tropical cities. EOS, Transactions, American Geophysical Union, 86, 397, 403.

Hinkel, K.M., Nelson, F.E., Klene, A.E. and Bell, J.H. 2003. The urban heat island in winter at Barrow, Alaska. International Journal of Climatology, 23, 1889-1905.

	Jáuregui, E. 2005. Possible impact of urbanization on the thermal climate of some large cities in Mexico. Atmosfera,18, 249-252. Liu, X. and Chen, B. 2000. Climatic warming in the Tibetan Plateau during recent decades. International Journal of Climatology, 20, 1729-1742. Oke, T.R. 1973. City size and the urban heat island. Atmospheric Environment, 7, 769-779. Streutker, D.R. 2003. Satellite-measured growth of the urban heat island of Houston, Texas. Remote Sensing of Environment, 85, 282-289. Zhou, L., Dickinson, R.E., Tian, Y., Fang, J., Li, Q., Kaufmann, R.K., Tucker, C.J. and Myneni, R.B. 2004. Evidence for a significant urbanization effect on climate in China. Proceedings of the National Academy of Sciences, 101, 9540-9544.
Continued	Chen, L., Zhu, W., Zhou, X. and Zhou, Z. 2003. Characteristics of the heat island effect in Shanghai and its possible mechanism. Advances in Atmospheric Sciences, 20, 991-1001. Chung, U., Choi, J. and Yun, J.I. 2004. Urbanization effect on the observed change in mean monthly temperatures between 1951-1980 and 1971-2000. Climatic Change, 66, 127-136. De Laat, A.T.J. and Maurellis, A.N. 2004. Industrial CO2 emissions as a proxy for anthropogenic influence on lower tropospheric temperature trends. Geophysical Research Letters, 31,1029. Frauenfeld, O.W., Zhang, T. and Serreze, M.C. 2005. Climate change and variability using European Centre for Medium-Range Weather Forecasts re-analysis (ERA-40) temperatures on the Tibetan Plateau. Journal of Geophysical Research,

110, 1029.

Gonzalez, J.E., Luvall, J.C., Rickman, D., Comarazamy, D., Picon, A., Harmsen, E., Parsiani, H., Vasquez, R.E., Ramirez, N., Williams, R. and Waide, R.W. 2005. Urban heat islands developing in coastal tropical cities. EOS, Transactions, American Geophysical Union, 86, 397, 403.

Hinkel, K.M., Nelson, F.E., Klene, A.E. and Bell, J.H. 2003. The urban heat island in winter at Barrow, Alaska. International Journal of Climatology, 23, 1889-1905.

Jáuregui, E. 2005. Possible impact of urbanization on the thermal climate of some large cities in Mexico. Atmosfera,18, 249-252.

Liu, X. and Chen, B. 2000. Climatic warming in the Tibetan Plateau during recent decades. International Journal of Climatology, 20, 1729-1742.

Oke, T.R. 1973. City size and the urban heat island. Atmospheric Environment, 7, 769-779.

Streutker, D.R. 2003. Satellite-measured growth of the urban heat island of Houston, Texas. Remote Sensing of Environment, 85, 282-289.

Zhou, L., Dickinson, R.E., Tian, Y., Fang, J., Li, Q., Kaufmann, R.K., Tucker, C.J. and Myneni, R.B. 2004. Evidence for a significant urbanization effect on climate in China. Proceedings of the National Academy of Sciences, 101, 9540-9544.

Our conclusion	UHI have significant impacts of measured trends. It is likely a large fraction of the 0.6 C warming reported for the 20th century is caused by spurious non-climatic effects such as UHIs. If 0.10 C/decade represents the warming in the central portions of towns and cities, as both pro and con arguments suggest, then it is reasonable to assume most temperature measurements are away from the center, so the UHI trends might be a quarter or a half of the central cities or 0.025 C to 0.05 C/decade. Kalnay suggests it is 0.027 C/decade over the US and this probably the most reliable number we have so far. That would mean about 45% of the observed warming is actually spurious urban warming.

Author:

Doug Hoyt
dhoyt@toast.net

See more about Doug at the Warwick Hughes web site:
http://www.warwickhughes.com/hoyt/climate-change.htm

Other Warwick Hughes Links and his blog
http://www.warwickhughes.com/