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Comment on "Unresolved issues with the assessment of multidecadal global land surface temperature trends" by Roger A. Pielke Sr. et al.

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1. Introduction

[1] We note *Pielke et al.*'s [2007] many concerns with the historical global mean land surface air temperature record, which range from the inclusion of nocturnal temperature observations to the importance of factoring in humidity. We will, however, limit our comments to two of *Pielke et al.*'s [2007] eight aspects where our additional analyses have shed considerable light.

2. Degree of Independence of Land Surface Global Surface Temperature Analyses

[2] According to *Pielke et al.* [2007], the similarity of the different global surface temperature trends is unsurprising, in view of an estimated overlap of 90% to 95% in the raw data. Regional temperature trends are considered to be less robust in data-sparse regions such as parts of Africa and the Arctic and Antarctic.

[3] Effectively independent analyses of land surface global temperature trends have already been carried out. *Peterson et al.*'s [1999] subset of rural stations showed very similar trends to those derived from the full GHCN data set. Using a worldwide network of about 270 stations, *Parker* [2006] obtained very similar trends to those produced by *Jones and Moberg* [2003] from their full network. The sensitivity of estimated land surface global temperature trends to analysis technique was estimated by *Vose et al.* [2005]. This paper showed that the *Smith and Reynolds* [2005] and the *Jones and Moberg* [2003] analyses yield comparable trends but the *Hansen et al.* [2001] and K. M. Lugina et al. (Monthly surface air temperature time series area averaged over the 30-degree latitudinal belts of the globe, 1881–2005, in Trends: A Compendium of Data on Global Change, 2006, an online report available at http://cdiac.ornl.gov/trends/temp/lugina/lugina.html) analyses yield reduced trends in recent decades because of the greater oceanic influence on the former and the damping influence of optimal interpolation on the latter [*Trenberth et al.*, 2007]. The generally good agreement between the global trends of land surface global temperature and the independent sea surface temperature and marine air temperature is also illustrated clearly by *Trenberth et al.* [2007]. Here we conduct an extra experiment: the CRUTEM3 land surface air temperatures [*Jones and Moberg*, 2003; *Brohan et al.*, 2006] have been subsampled by taking, in each month, alternate 5° × 5° areas in alternate 5° latitude belts. Figure 1 shows annual global (Figure 1a) and hemispheric (Figures 1b and 1c) average land surface air temperature anomalies for 1850–2007 based on the full database, with uncertainty estimates as in work by *Brohan et al.* [2006], along with series based on the two sets of locations in Figure 1d. The subsampled series, despite being based on essentially independent data, lie well within the uncertainty estimates since 1900, and are usually within the uncertainty estimates even in the sparsely sampled 19th century, confirming the robustness of all the series. Not only do these analyses use completely different stations, but any adjustments applied are also independent owing to the distances between the stations that contributed to the two sets of 5° × 5° areas. In essence, the independence of the station data in the subsampled 5° × 5° areas cannot be compromised by the homogeneity adjustments reported in earlier papers (see sources given by *Jones et al.* [1986a, 1986b]), or through the inclusion of many additional adjusted data sets by *Jones and Moberg* [2003]. This is because adjustments were made to only a limited number of stations (~20%), and almost all of these adjustments will have been based on stations within the same or surrounding 5° × 5° areas, not on remoter stations. Furthermore the sum total of the adjustments has a near zero effect on large-scale temperature averages [see *Brohan et al.*, 2006, Figure 4].

[4] The spatial coherence of mapped temperature trends, transcending international borders as illustrated for example in Figures 3.9 and 3.10 of *Trenberth et al.* [2007], suggests strongly that recent global and regional trends are not severely affected by national biases or incomplete coverage. The latter inference can also be drawn from the relatively small numbers of spatial degrees of freedom estimated by *Jones et al.* [1997]. *Brohan et al.* [2006] estimated global and hemispheric incomplete-coverage errors by subsampling complete reanalysis fields; since the mid-20th century the 95% confidence range for decadally smoothed global land surface air temperature anomalies has been about 0.25°C and this is mainly due to incomplete-coverage error [*Brohan et al.*, 2006, Figure 12]. However, the robustness of estimated trends for earlier periods and smaller regions is

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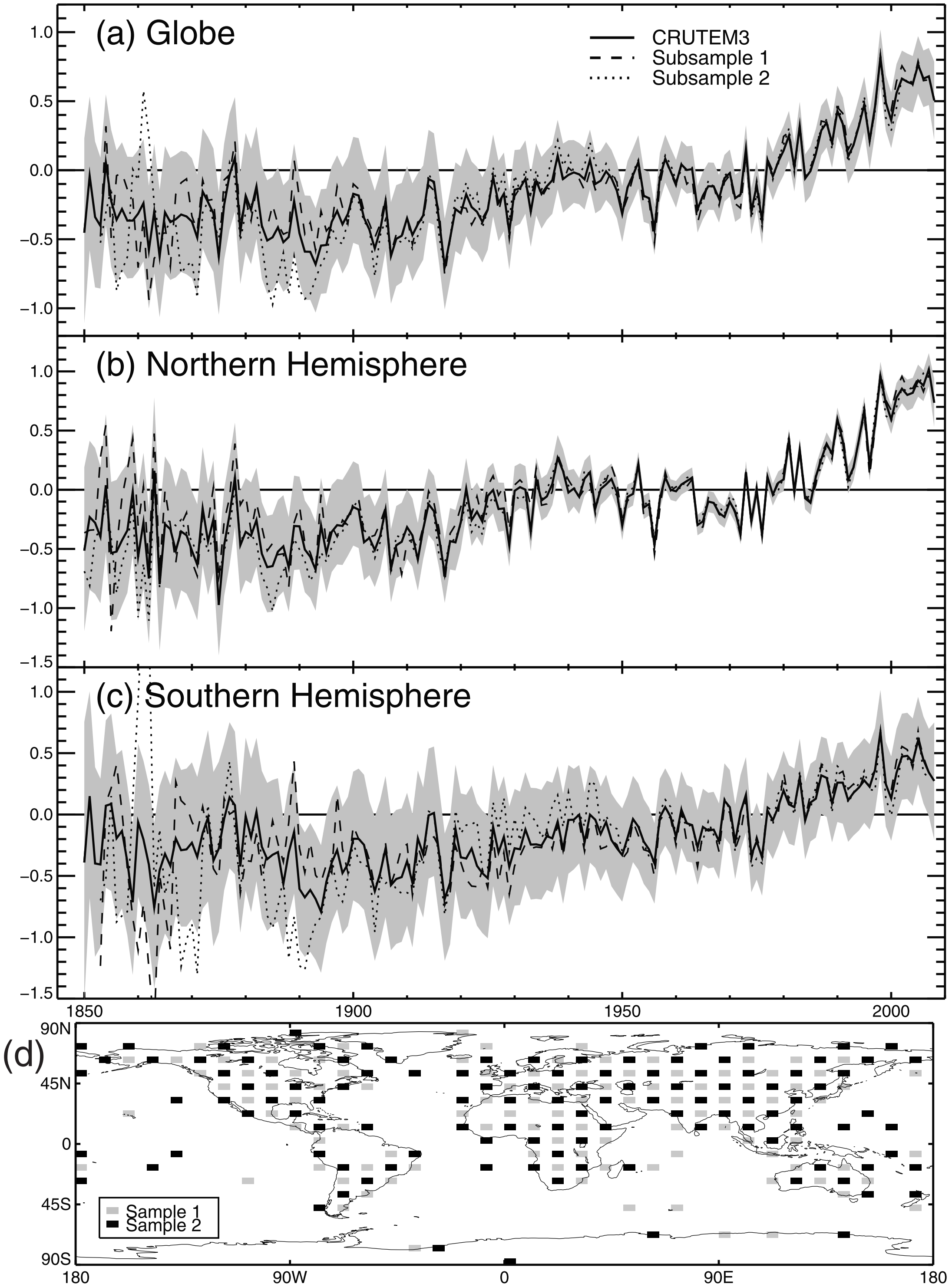

Figure 1. Annual (a) global and (b and c) hemispheric average land surface air temperature anomalies (°C relative to 1961–1990) for 1850–2007 for the full database (solid line), with 5% to 95% uncertainty ranges (shading) as in work by *Brohan et al.* [2006], and for two samples (dashed and dotted lines) and (d) their locations.

more affected by the incomplete coverage. *Brohan et al.* [2006] also estimated the sampling errors of land surface air temperature on a monthly basis for 5° latitude × 5° longitude boxes. The sampling errors were greatest at high latitudes where temporal temperature variability is large and there are few stations per grid box, supporting *Pielke et al.*'s [2007] remarks, and underlining the need for improved polar monitoring and for flexible gridding according to the application of the analysis [*Brohan et al.* [2006].

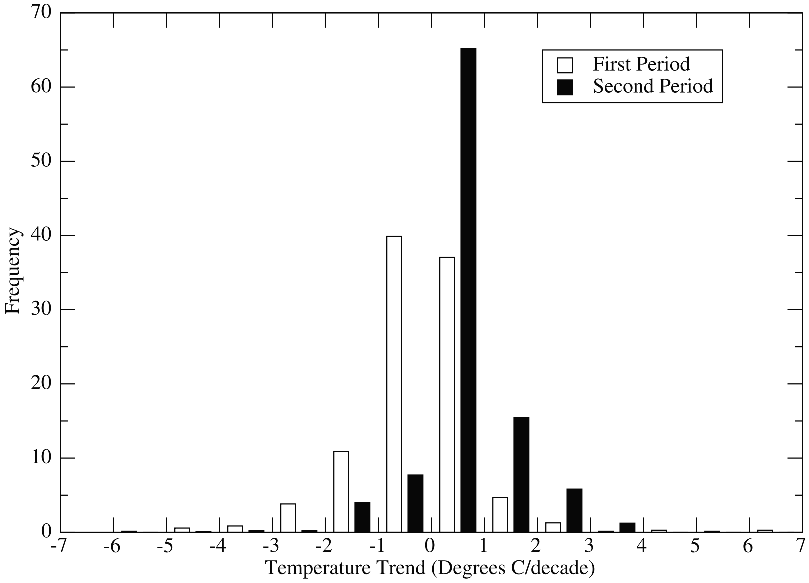

Figure 2. Histogram of significant trends in SST grid boxes using the "before dominant land use/cover change" dates at *Hale et al.*'s [2006] stations (first period) and "after dominant land use/cover change" period (second period). Note that the second period has substantially more grid boxes with warming trends and fewer with cooling trends.

[5] In summary, these criticisms by *Pielke et al.* [2007] of the global and hemispheric land surface air temperature anomaly series are not supported by several existing analyses or by our new analysis. On smaller scales and during data sparse times, uncertainties in trends need to be narrowed by rescue and incorporation of all existing historical data.

3. Influence of Land Use/Land Cover (LULC) on Surface Temperature Trends

[6] *Pielke et al.*'s [2007] final results extend those of *Hale et al.* [2006] in analyzing temperature trends in the conterminous United States before and after major changes in LULC. They find increased trends after these changes and state that this affirms the possibility that nearby changes in LULC may be influencing the trends.

[7] We point out that if the changes in LULC had caused the trends, similar changes would not have occurred where there were no changes in LULC. To illustrate this, we conducted an analysis identical to that of *Hale et al.* [2006] except for two key differences. The first difference is that rather than using land surface station air temperature data, we used sea surface temperature (SST) data [*Smith and Reynolds*, 2004] over the Atlantic and Pacific Oceans in the same latitude zone as the *Hale et al.* [2006] stations, 26°N to 48°N. Time series at each 2° × 2° grid box from 1971 to 2000 were analyzed using the same approach that *Hale et al.* [2006] applied to land surface station time series for that time period except for the second difference. Instead of dividing the time series into two sections on the basis of local land use changes, grid box SST time series were divided into two sections by sampling the same exact periods used by *Hale et al.* [2006] for their stations. As there were 1268 SST grid boxes with data in the area analyzed, the dates used at 170 of the 183 Hale et al. stations were applied to 7 grid boxes each, and the dates at the remaining 13 stations were applied to 6 SST grid boxes each. The results of this analysis are shown in Figure 2, which is equivalent to *Hale et al.*'s [2006] Figure 3 and similar to *Pielke et al.*'s [2007] Figure 26. Like these two figures, our results show lower trends in the first part than the second part. Indeed, the mean trend of the 707 grid boxes with significant trends for the first part is −0.20°C per decade while the mean trend of the 894 grid boxes with significant trends for the second part is 0.58°C per decade. As similar changes in trends occur where no local LULC change is possible, these results indicate that *Pielke et al.*'s [2007] analysis of changes in LULC simply coincided with the inception of externally imposed large-scale warming.

[8] We do not deny that LULC changes can cause significant surface air temperature changes, as shown in several papers cited by *Pielke et al.* [2007]. However, for *Hale et al.* [2006] to have demonstrated LULC effects, their calculated trends should have spanned the LULC changes, not followed them. Their subsequent analysis [*Hale et al.*, 2008] was correct in comparing post- with pre-LULC-change averages, but it relies on the NCEP-NCAR Reanalysis being homogeneous which is very unlikely [see *Simmons et al.*, 2004], so this is a serious flaw in their comparisons. This aspect would be partly addressed by using the ERA-40 Reanalyses as well as those from NCEP-NCAR.

4. Conclusions

[9] Prompted by *Pielke et al.*'s [2007] concerns, we have provided an additional demonstration of the robustness of global and hemispheric land surface air temperature series. We have shown that *Pielke et al.*'s [2007] attribution of changed temperature trends to local LULC changes is not firmly based. We nevertheless agree with *Pielke et al.*

[2007] in aspirations for an improved global network monitoring all Global Climate Observing System (GCOS) Essential Climate Variables including humidity as well as temperature; for universal adherence to the GCOS Climate Monitoring Principles (http://www.wmo.ch/pages/prog/gcos/index.php?name = monitoringprinciples) which include the availability of full metadata such as photographic documentation; and as well for the rescue and digitization of all historical data.

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