Reply to comment by W. M. Connolley on "Was the 2003 European summer heat wave unusual in a global context?"

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[1] We agree with *Connolley* [2008] that the 2003 heat wave as measured by the near surface temperature does indeed appear to be much more unusual than the 1000–500 mb depth-averaged anomaly. We chose, however, the averaged temperature to characterize the heat wave for several reasons. First, a layer average permits a more comprehensive assessment of large scale temperature anomalies than do single point, near-surface temperature anomalies which are more affected by local conditions [e.g., see, *Pielke et al.*, 2007]. Secondly, unlike the depth averaged temperatures which are strongly observationally based, the near-surface, NCAR-NCEP reanalysis temperature is not directly constrained by observations and is therefore, in large part, a model calculation [*Kalnay et al.*, 1996]. Errors in such quantities as soil moisture distribution in the reanalysis (a weakness of most models), for example, would make the calculation of near-surface temperature extremes less precise, especially in a situation where soil moisture seems to have played a strong role. For example, a too dry soil would spuriously amplify a warm anomaly. Finally, the effects of increasing anthropogenic CO_2 on atmospheric temperature are expected to extend vertically through the troposphere, at least climatologically [*Trenberth et al.*, 2007; *Climate Change Science Program*, 2006]. Assuming the near-surface temperature measurements are spatially representative, the conclusion that the heat wave was a shallow phenomenon in terms of its unusualness argues against the point of view that it was a direct manifestation of the effects of increased atmospheric CO_2 (note the use of ''SD thresholds exceeded'' normalizes variability with altitude making all levels directly comparable).

[2] Therefore we also conclude that land surface conditions (low soil moisture) are the likely direct cause for such an ''unusual'' event near the surface. This is supported by *Fischer et al.* [2007] who reported the lack of rainfall the preceding spring as an important contributing factor in enhancing the 2003 heat wave. Many processes could be responsible for the lack of previous season rainfall including regional processes and natural or anthropogenic changes in circulation patterns.

[3] Figure 1 updates *Chase et al.* [2006] through 2006 for 2.0 and 3.0 SD levels and adds to our original conclusion that 2003 was not very unusual in terms of the spatial coverage of extreme depth-averaged temperatures. For example, the summer of 2004 also exceeded the 2003 warm anomaly extent. This was due to a strong Alaskan heat wave which produced a record breaking wildfire season documented in *National Climatic Data Center*'s [2004] Annual Climate Report (http://www.ncdc.noaa.gov/oa/climate/research/2004/ann/events.html), but otherwise received much less public attention than the European heat wave. However, the addition of three additional summers (2004–2006) to the time series, all of which appear to be relatively warm, now indicates the possible emergence of an upward trend as suggested in previous work [*Stott et al.*, 2004]. For example 2.0 SD warm anomalies now appear to have an upward trend ($p = 0.05$) though this trend should be viewed with caution because of the small sample size and the dominant effect of data points at the end of the series. The rise in 3.0 SD anomalies comparable to the 2003 heat wave is, however, still insignificant ($p = 0.16$) and so the increased probability of such extremes with time suggested by *Stott et al.* [2004] is not yet apparent.

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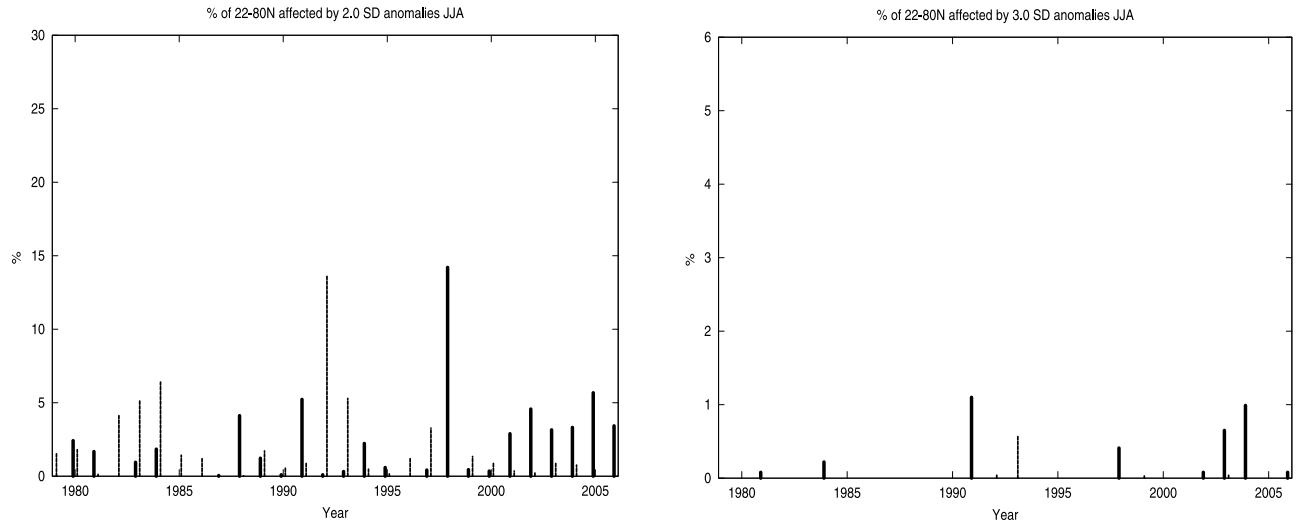

Figure 1. Percentage of the Earth from 22–80 N exceeded by (left) 2.0 SD anomalies and (right) 3.0 SD anomalies for 1979–2006. Warm anomalies are dark, solid lines; cold anomalies are grey, dashed lines.

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