is a station that has undergone several such changes (including instrumentation replacements in 1985, 1993 and 1998). Kalnay and Cai use raw data in their analysis but indicate that data adjustments for these non-climatic changes should result in a larger estimate of the impact of urbanization and other changes in land use.

To determine the effect of non-urban data adjustments, we performed an analysis identical to that of Kalnay and Cai, except that we used data from the US Historical Climatology Network (HCN) database[3]. The HCN is well suited for this purpose because it contains corrections that account for changes in observation time, instrumentation and location (adjustments for urbanization are also available, but were not used here because most HCN stations are in rural settings). We applied Kalnay and Cai's station-selection criteria to HCN, which yielded a set of 834 stations that are well distributed in their study area. We then used the authors' method to calculate the trend for the corrected HCN data for the period 1960–1999.

The resulting mean temperature trend in HCN (+0.224 °C per decade) exceeds Kalnay and Cai's observed temperature trend (+0.112 °C per decade). By the authors' reasoning, the difference between the HCN trend (+0.224 °C per decade) and the NNR trend (+0.077 °C per decade) is due to changes in land use. This trend difference (0.147 °C per decade) far exceeds their land-use value (0.035 °C per decade) and is ten times the size of the largest published urban estimate for the United States (0.015 °C per decade[4]). It also indicates that land-use change accounts for two-thirds of the warming over the past four decades. (The effect would have been even larger had a more urban network been used.)

In addition, this trend difference is decreasing over time. According to our calculations, the discrepancy between the corrected HCN trend and the NNR trend during the first two decades (0.202 °C per decade) is more than twice as large as during the past two decades (0.089 °C per decade).

These estimates seem improbable and indicate to us that the NNR trends are not accurate. We infer this in part because there is extensive evidence to support corrected HCN trends; they are spatially consistent with surface trends across international borders, with sea-surface temperature trends in adjacent oceans (which had no change in land use), and with tropospheric temperature trends derived from satellites and radiosondes[5].

We are not aware of any evidence demonstrating the reliability of the NNR surface-temperature trends. Neither can we think of a reason why the land-use effect should have decreased by more than 50% during the study period. The decrease in the NNR land-use estimate is particularly striking given the dramatic increase in temperature during the past two decades[6] (+0.343 °C per decade in HCN).

Our results indicate that the NNR alone is not sufficient to identify a land-use impact, casting doubt on Kalnay and Cai's conclusions. However, their work does draw attention to an important issue that requires further investigation.

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Cai and Kalnay reply — We do not deny the obvious importance of global warming and decrease in diurnal temperature range (DTR) due to greenhouse effects, which are present in both surface-station observations and the NCEP/NCAR 50-year reanalysis (NNR). Moreover, the NNR shows the largest warming trend over the past two decades, as reported in the surface-station data, suggesting that the NNR captures the dominant greenhouse-warming effect.

Our study[1] attributes the differences between the two data sets largely to land-use changes because the NNR is not subject to local surface influences. We deliberately used raw (unadjusted) surface observations and pointed out that the multiple non-climatic adjustments are uniformly positive, so our estimate should be considered as the lower bound of the effect of land-use changes. As we pointed out and Vose *et al.* confirm, adding these non-climatic adjustments to our lower-bound estimate does not alter the sign of the estimated land-use change effect but increases its magnitude.

Trenberth's comment that the reanalyses do not include the effects of the changing atmospheric composition seems to be based on the common misunderstanding that if the model used as a first guess does not have a carbon dioxide trend, for example, then the reanalysis may at best include only a 'watered-down' greenhouse-warming trend.

We showed by using an analytical study that the reanalysis can capture essentially the full strength of climate trends caused by the increase in greenhouse gases, even if this forcing is absent from the model used in the data assimilation (our unpublished data). This is because the reanalysis assimilates atmospheric temperatures and other observations that are affected by greenhouse gases and other changes. We point out that, even though the model has no volcanic aerosols, a reanalysis can capture the atmospheric heating resulting from volcanic eruptions[2].

The fact that both station observations and the NNR exhibits a decrease in DTR reflects the impact of an increase in low-level clouds[3]. However, the surface observations show an even larger decrease in DTR, and we attribute the difference largely to land-use changes. This agrees with previous studies showing that urban effects also have a substantial impact on the decrease of DTR[4].

The non-climatic adjustments can be added *a posteriori* to our estimate, leading to an upper-bound estimate of the impact of land-use changes. According to the calculations made by Vose *et al.*, the non-climatic adjustments to these raw station observations yield an averaged increase of 0.112 °C per decade. In other words, half of the averaged increase between 1960–1979 and 1980–1999 derived from the HCN data set (0.224 °C per decade) is the result of the non-climatic adjustments to the raw station observations.

Adding these non-climatic adjustments to our lower-bound estimate of the impact of land-use changes (0.035 °C per decade) yields 0.147 °C per decade. This upper-bound estimate is comparable to another study that also used the HCN data (0.12 °C per decade[5]). Therefore, the upper-bound estimate is not ten times the size of the largest published urban estimates for the United States.

We found that a decrease in the effect of total land-use change in 1960s–1970s to 1980s–1990s took place, primarily, over the rural stations. Reforestation, saturation of urban heat-island effects, and more regulated land-use changes could be leading factors resulting in such a decrease in land-use change. This decrease is independent of, and in no way contradicts, the "dramatic increase in temperature during the past two decades" because the NNR estimate also registers a larger increase in the daily mean surface temperature equal to 0.254 °C per decade over the past two decades, which is comparable with the estimate (0.343 °C per decade) derived from the HCN data set.

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