Comment on "Impact of urbanization and land-use change on climate" by E. Kalnay and M. Cai, *Nature*, **423**, 528-531; doi 10.1038/nature01675

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Kalnay and Cai use the surface temperatures from NCEP/NCAR reanalyses (NNR) and their comparison with observed station surface temperatures to infer that there has been a major impact of urbanization and land use change on climate. However, there are alternative explanations for their findings.

The NNR utilize upper air observations to produce global analyses every 6 hours of atmospheric fields at about 1.9• resolution using a four-dimensional data assimilation that capitalizes on available multivariate data. A consequence of the analysis procedures is that NNR do not include local surface influences or observations, and the rationale of the authors is that this allows the differences to be interpreted in terms of land use and urbanization. However, the reanalyses do not utilize a lot of other information either. They do not include effects of the changing atmospheric composition on radiation. Yet carbon dioxide concentrations in the atmosphere increased from 318 ppmv in 1960 to over 370 ppmv, about a 17% increase, in this time. Nor do they deal with changes in surface wetness. Positive trends in cloudiness and rainfall over the Mississippi River Basin have increased evaporation while decreasing potential evapotranspiration[2], and these trends should have an important influence on the surface heat balance.

However, the NNR also does not assimilate clouds, and the depiction of clouds in the NNR is poor, so that the surface heat budget is seriously in error[3]. Detailed studies of the surface heat budget and of why minimum temperatures are increasing at a faster rate than maximum temperatures reveal that the decreasing diurnal temperature range (DTR) is linked to the world-wide increases in cloud cover[4]. Clouds greatly reduce DTR by sharply decreasing surface solar radiation while reducing radiative losses at night. Processes involved in DTR, including all radiative terms, surface fluxes of sensible and latent heat, and soil moisture effects, have been extensively examined using comprehensive measurements from the First International Satellite Land Surface Climatology (ISLSCP) Field Experiment (FIFE) over the Konza Prairie in Kansas[4]. Changes in clouds, especially low clouds, largely determine the patterns of change of DTR. Soil moisture also has an influence of decreasing DTR by increasing daytime surface evaporative cooling. Empirical relationships[4] are used with synoptic observations to extend the results globally, and it is found that DTR varies inversely with cloud cover and precipitation on multiple time scales, in particular, over the United States (and elsewhere). The reported decreases in DTR are therefore consistent with the reported increases in cloud cover.

Other studies have explored the relationships with surface vegetation. Over the southern two-thirds of the Eastern United States the DTR peaks in spring and autumn with minima in winter and mid-to-late summer[5] and changes in DTR are traceable to the lengthening growing season, especially on sunny days, so that the increases in vegetation and associated evapotranspiration are important. Moreover, direct assessment of effects of changes in land use and vegetation[6,7] show that conversion of forest to crop-land generally causes a decrease in radiative forcing through an increase in albedo, which is greatest after the harvest in the autumn. This results in a relative cooling, estimated in model studies to be in excess of 1•C in autumn[6], due to changes in land use, rather than a warming[1]. After the 1960s the biggest land use changes have been for increases in crop-land area in the Midwest U.S. but decreases with reforestation in the Northeast[6]. By contrast, urban heat island effects are localized in cities whose stations are usually not used in compilations of climate change. However, changing snow cover is a contributing factor for DTR in winter over the United States[8].

Changes in cloudiness and surface moisture are likely the main sources of the discrepancies in trends found by Kalnay and Cai[1] along with deficiencies in the NNR in terms of its ability to deal with these influences and other diabatic processes that affect the surface heat budget. While urban heat island effects are real in cities and present in many of the uncorrected records used, there is no evidence to show that urbanization and land use changes are responsible, as claimed.

References

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