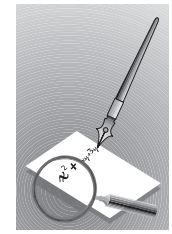
commentary and analysis



Comments on "Changes in the Onset of Spring in the Western United States"
Reply

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The article by Cayan et al. (2001) in the March issue of the *Bulletin* is an interesting approach to observing regional climate changes. Before it can be taken very seriously, however, I believe that the authors need to consider some kinds of bias present in all climate data, instrumental or biological. A particular bias that has disturbed climate observations in the last century or two is the changing character of a site's environment, particularly population growth and urbanization. The effect of urban heat islands is a well-known cause of increased temperature, one which is most notable for stations that remain fixed in space while the environment around them changes. It does not appear that the Cayan et al. study took note of that effect. As a typical example of the problem, consider Norman, Oklahoma, a small city with a population of about 100 000, which has more than doubled, along with even larger increases in energy utilization, in the last 30 years or so. On a couple of recent occasions I had students do observational cross sections from mobile weather stations, north–south and east–west across the city and its rural environment. They usually found temperatures two or three degrees warmer in the city. I live about 5 miles from the city center, in a mostly forested area. I have noticed that lilacs, daffodils, and fruit trees inevitably bloom a week or two earlier in town than in my rural garden, and both maximum and minimum temperatures are lower here. Fifty years ago this was probably much less the case. Since Cayan et al. specifically used stations with a fairly long record, it is very likely that similar effects are present and may account for at least some of the apparently increased spring temperatures.

I am not totally convinced by the author's response, but believe it is useful to readers to view the correspondence. Their defense seems to rely largely on the regional instrumental climate record, but that too may be biased.

References

Cayan, D. R., S. Kammerdiener, M. D. Dettinger, J. Caprio, and D. H. Peterson, 2001: Changes in the onset of spring in the Western United States. *Bull. Amer. Meteor. Soc.,* **82,** 399–415.

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Reply

We thank Dr. Lilly for his comment (Lilly 2001) concerning the possibility that the trend toward early lilac and honeysuckle bloom that we noted in our recent (Cayan et al. 2001) study may have been caused by urbanization. For some individual lilac or honeysuckle bushes, it is very possible that such an urban influence could be operating. Unfortunately, because the phenological network has vanished after it was retired in 1994, it is virtually impossible to examine this directly from site inspections. However, the circumstantial evidence that this trend is a symptom of regional and larger-scale climate fluctuations or changes, *not* from local urban effects, is quite strong, as explained below.

First, most of the phenological observers were located in rural areas, and not likely to experience large

urban heat islands. Moreover, the observed changes in timing are quite broad in scale, and their close correspondence to temperature changes is true not only for the general trend but for their year-to-year changes in patterns (see Figs. 6 and 9 of Cayan et al. 2001). The overall temperature trend, shown in our Fig. 1, which correlates strongly with the first mode of lilac bloom timing variability, is clearly a continental feature.

Second, a major thrust of this paper was that the temperature fluctuations and trends were picked up by very different recorders. It is pretty convincing that a second, and somewhat independent honeysuckle dataset exhibits trends and patterns nearly identical to those of the lilacs (Figs. 6 and 7 of Cayan et al. 2001), and both are well-correlated to regional temperature change. Additionally, the changes toward earlier plant bloom are mirrored by changes toward earlier snowmelt runoff in western rivers. The United States Geological Survey high-elevation basins included were selected because they were relatively free of disturbances, thus the signal we find is quite surely a regional climate response rather than an artifact of human intervention. Just as these undisturbed river basins act as vast precipitation gauges for many hydroclimatic studies, in this case they serve as regional thermometers in integrating yearly temperature changes and trends over hundreds of square kilometers. Since these high-elevation watersheds are by and large remote wilderness areas, there is little chance that these have any urban effects. The first EOFs of the lilac bloom timing and streamflow spring pulse timing have similar spatial patterns and have temporal variability that correlates at $r = 0.78$ (Figs. 11 and 13, and discussion on pp. 410 and 411 of Cayan et al. 2001).

Third, the secular trends in lilac bloom timing, spring streamflow pulse timing, and *regional* spring temperature relate to one another in very nearly the same way as do their interannual fluctuations, as discussed in section 5 and detailed in Table 3 of Cayan et al. (2001). If there was a local influence, it seems unlikely that this regional temperature/bloom timing balance would remain the same. Indeed, concerning the lilac response, both secular changes and interannual fluctuations amount to about 4 to 5 days of advance in bloom per Celsius degree of regional temperature anomaly.

Finally, the relations between lilac bloom timing and atmospheric circulation patterns (Fig. 10 of Cayan et al. 2001), and between spring runoff timing and atmospheric circulation patterns (Dettinger and Cayan 1995), are both consistent with large-scale atmospheric forcing of the trends toward earlier and warmer springs. Dettinger and Cayan (1995) furthermore showed that the attendant circulation changes were large enough to explain the magnitude of the observed regional temperature trends. It is unlikely that urban effects are inducing trends in atmospheric circulations over the entire Pacific–North American sector, so we see little reason to believe the primary mechanism at work is local.

References

Cayan, D. R., S. Kammerdiener, M. D. Dettinger, J. Caprio, and D. H. Peterson, 2001: Changes in the onset of spring in the western United States. *Bull. Amer. Meteor. Soc*., **82,** 339–415.

Dettinger, M. D., and D. R. Cayan, 1995: Large-scale atmospheric forcing of recent trends toward early snowmelt runoff in California. *J. Climate,* **8,** 606–623.

Lilly, D., 2001: Comments on "Changes in the onset of spring in the western United States." *Bull Amer. Meteor. Soc.,* **82,** 2263.

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