Air Quality False Alarm

An Analysis of the Natural Resource Defense Council's Heat Advisory Report

United for Jobs

The Buckeye Institute for Public Policy Solutions

Commonwealth Foundation for Public Policy Alternatives

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An Analysis of the Natural Resource Defense Council's *Heat Advisory* Report

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Introduction

Heat Advisory, a recent report from the Natural Resources Defense Council (NRDC), claims that increased temperatures resulting from global warming will cause higher ozone smog levels and therefore harm Americans' health. In other words, in addition to other harms, NRDC claims global warming will cause future air pollution to be worse than current air pollution levels. For example, NRDC asserts that the number of days per year exceeding the Environmental Protection Agency's (EPA) 8-hour ozone standard will increase by an average of 60 percent in America's metropolitan areas.

This report shows that air pollution will decline in the future, regardless of whether there is global warming, and that NRDC exaggerates likely future temperature increases in any case. Section II lays out the major points of our critique of the NRDC report. Section III includes specific responses to the report's claims. Section IV displays trends in air pollution and temperature in a number of metropolitan areas, including the fifteen areas that NRDC focuses on in its report.

Overview

NRDC commissioned several distinguished university and government scientists to research and write *Heat Advisory*. Despite the qualifications of the authors, the report's analysis is faulty and its conclusions are false and misleading. Although urban temperatures have increased an average of 1-3 degrees Fahrenheit (F) during the last 30 years, air pollution has declined across the United States. NRDC created the appearance that ozone will increase in the future by assuming that ozone-forming emissions 50 years from now will be the same as they were eight years ago. In other words, rather than predicting future ozone levels, NRDC actually estimated what ozone levels would have been back in 1996 if 1996 had been a few degrees hotter.

This has nothing to do with what ozone levels will be in the future. Ozone-forming emissions are already well below the 1996 levels assumed by NRDC, and will only continue to decline. Air quality will continue to improve, regardless of future climate, because requirements that have already been adopted and/or implemented will eliminate most remaining air pollution emissions in coming years. At worst, future temperature increases will slow the rate of future ozone declines.

But *Heat Advisory*'s conclusions would be false even if pollution emissions remained constant, because the net effect of a warming climate would be less harm from air pollution. This is because higher temperatures reduce fine particulate matter (PM2.5) more than they increase ozone. Furthermore, PM2.5 is more strongly associated with health effects than ozone in epidemiological studies. As a result, increased temperature would be a net benefit for air pollution and health.

Regardless of future pollution levels, NRDC's report also exaggerates future warming. The report's climate change predictions rest on the supposition that future warming will occur due to increases in greenhouse gases, particularly carbon dioxide (CO_2). The report employs the Intergovernmental Panel on Climate Change's (IPCC) A2 scenario, which is in the medium-high range of IPCC warming projections. The scenario predicts an average global temperature increase of nearly 7 degrees Fahrenheit between 1990 and 2100. However, warming of this magnitude is unlikely. The climate models used by the IPCC predict that once warming begins, it increases linearly with exponential increases in CO_2. This suggests that a linear extrapolation of past trends is a reasonable guide to future warming. The linear trend in U.S. temperature from 1900-2000 suggests that average global temperature will rise about 0.7 degrees F between 2000 and 2100, well below the scenario used by NRDC.

Climate models also suggest that most warming in a greenhouse-warmed world will occur in the high latitudes, in winter, and at night. This is due to the fact that only in the driest air on the planet, which is also the coldest air, will water vapor be scarce enough to make carbon dioxide and methane anything more than minor greenhouse gases (water vapor is by far the most important greenhouse gas). Thus, whatever the extent of future warming due to CO_2 emissions, summer daytime temperatures in the United States will likely rise far less than global-average temperatures.

NRDC also disregards a key aspect of climate history: temperatures were as warm as or warmer during the 1930s than they are today. This earlier warming occurred prior to the large increases in CO_2 that began during World War II and continued through the ensuing decades. Thus, temperature increases from 1900 to 1940 must have been natural in origin. Nevertheless, regarding recent increases in global temperatures, NRDC claims natural climate variability "cannot explain the magnitude, rate, and pattern of the changes." In actuality, a number of natural climate factors *do* explain recent climate trends. These factors include variations in solar radiation and changes caused by ocean circulation cycles. Thus, while recent temperature increases might be due partly to human influences, they might also be largely natural in origin.

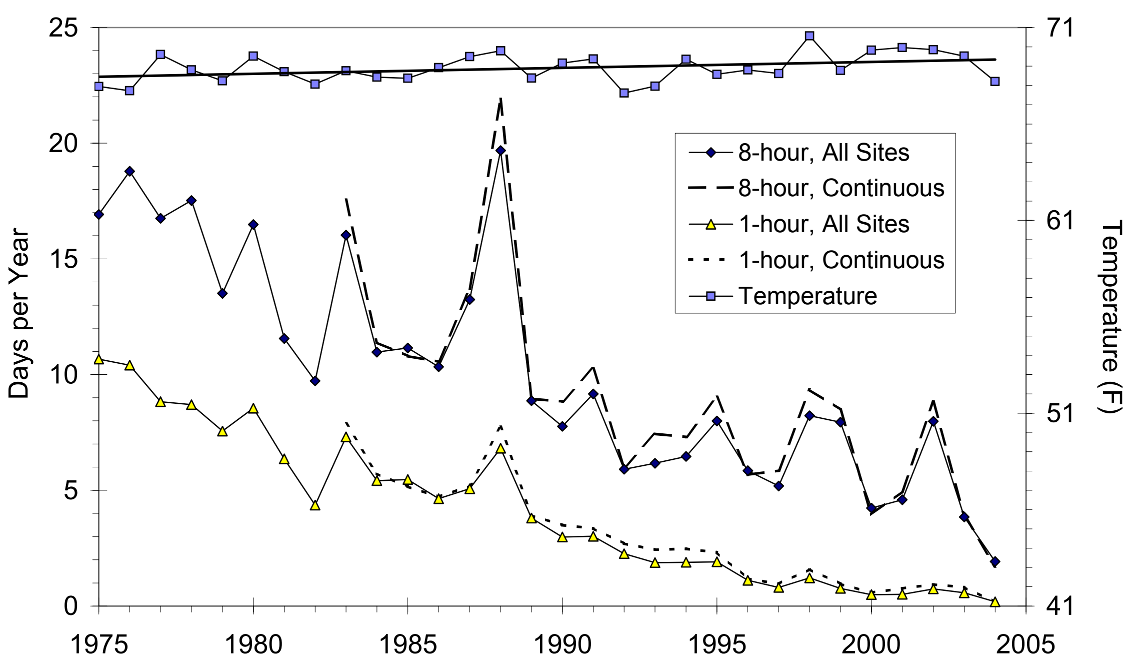
The rest of this section discusses these and other concerns in more detail and with citations to the relevant scientific and health literature.

During the last 30 years, urban temperatures have risen, yet ozone levels have declined. Urban temperatures have risen an average of 1-3 degrees Fahrenheit (F) during the last 30 years, yet ozone levels have fallen (National Climatic Data Center 2004). The temperature increase is due mainly to the urban heat island effect, rather than global climate change, as demonstrated by the fact that rural temperatures have risen more slowly than urban. For example, de Laat and Maurellis (2004) state "the 'real' global mean surface temperature trend is very likely to be considerably smaller than the temperature trend in the CRU [Hadley Center/Climate Research Unit global data set] data." Other researchers have published similar results (see e.g., Karl, Diaz et al. (1988)).

Nevertheless, despite increasing urban temperatures, the average number of exceedances per year of EPA's 8-hour ozone standard declined 75 percent from 1975 to 2004, while exceedances of the 1-hour standard declined 95 percent.[1] Figure 1 shows the trend in the national-average number of days per year with ozone exceeding EPA's 1-hour and 8-hour ozone standards for all ozone monitoring locations in the U.S. The graph also includes the national-average trend in peak daily summer temperatures in the U.S. from 1975 to 2004. Note the large variation in 8-hour ozone levels from year to year. These short-term variations are due to differences in weather from year to year, including not only temperature, but rain, wind, and other meteorological variables. Superimposed on these short-term variations is a long-term decline in ozone exceedance days due to ongoing reductions in ozone-forming emissions.

NRDC does mention that air pollution has improved during the last few decades, but does not give details beyond this general acknowledgment, and also fails to note that these pollution improvements occurred along with increasing temperatures.

Figure 1. Trend in National-Average Number of Days per Year Exceeding EPA's 8-hour and 1-hour Ozone Standards 1975-2004, and Trend in National-Average May-September Temperature



Notes: The graph displays the trend in ozone exceedances per year in two ways. "All Sites" provides the trend from 1975-2004 for all ozone monitoring sites that happened to be operating in a given year. This could create bias, because some

[1] The percentage change in ozone exceedances was determined based on a five-year moving average.

sites are added or removed in any given year. Thus, we also show a trend from 1983-2004 for only those sites that operated continuously during that 22-year period (258 "continuous" sites). The two trends are strongly correlated, showing that the "All Sites" trend provides a valid representation of the true trend in ozone exceedances. The national-average temperature trend is based on average daily temperatures from May through September of each year. A linear regression line shows the temperature rise over the last 30 years.

Sources: Ozone exceedances were calculated from data for all monitoring locations downloaded from EPA's Air Quality System (AQS), http://www.epa.gov/air/data/index.html. National temperature trend was downloaded from the National Climatic Data Center (NCDC), http://www.ncdc.noaa.gov/oa/climate/research/cag3/na.html.

The Appendix includes graphs of ozone and temperature trends in several metropolitan areas, including the 15 areas for which NRDC created future ozone scenarios and four additional areas. The graphs show that ozone has generally declined despite rising urban temperatures. In particular, 2003 and 2004 were record-low or near-record-low ozone years in most U.S. cities.

NRDC's report is based on the premise that increasing temperatures necessarily result in higher ozone levels. All else equal, this is true. But in the real world many factors vary from year to year, including other climate variables besides temperature, as well as emissions of ozone-forming pollutants. We can check the actual record of ozone exceedances and temperature to see how strongly temperature has predicted ozone levels in the past. It turns out that the relationship between temperature and ozone is not particularly strong in several of the cities assessed by NRDC. For example, there is little or no relationship between ozone and temperature (r-squared less than 0.1) in Atlanta, Buffalo, Charleston, Houston, Little Rock, Los Angeles, Nashville, New York, Pittsburgh, and Portsmouth. In other words, in seven of the 15 areas assessed by NRDC, and 10 of the 19 areas assessed in this report, the actual data suggest that higher temperatures and ozone exceedances are in practice uncorrelated.

NRDC created the appearance of higher future ozone levels by inflating future ozone-forming pollution emissions. Ozone is formed when nitrogen oxides (NOx) and volatile organic compounds (VOC) react on warm, sunny, calm days. NOx and VOC are therefore known as "ozone precursors." NRDC projects ozone levels for the 2050s using EPA's estimate of ozone-precursor emissions for 1996.[2]

NRDC takes EPA's 1996 emissions estimate and combines it with temperature projections for the 2050s to project future ozone levels. This approach vastly overestimates future ozone levels, because it assumes that ozone-forming emissions will remain at 1996 levels for decades to come. In fact, even current ozone-forming emissions are well below 1996 levels. NOx emissions declined at least 30 percent from 1996 to 2004, while VOC emissions declined about 50 percent. NRDC's ozone estimates are therefore inapplicable even to current ozone-precursor emissions, much less future emissions. We will show in the next sub-section that ozone-forming emissions will continue to decline.

Figure 2, from an EPA air pollution trends report, shows the trend in growth of population, energy use, vehicle miles, and GDP since 1970, when the Clean Air Act was signed into law. During that same period, EPA estimates emissions of the six principal air pollutants it tracks have declined steadily, and are now 51 percent lower than they were in 1970.

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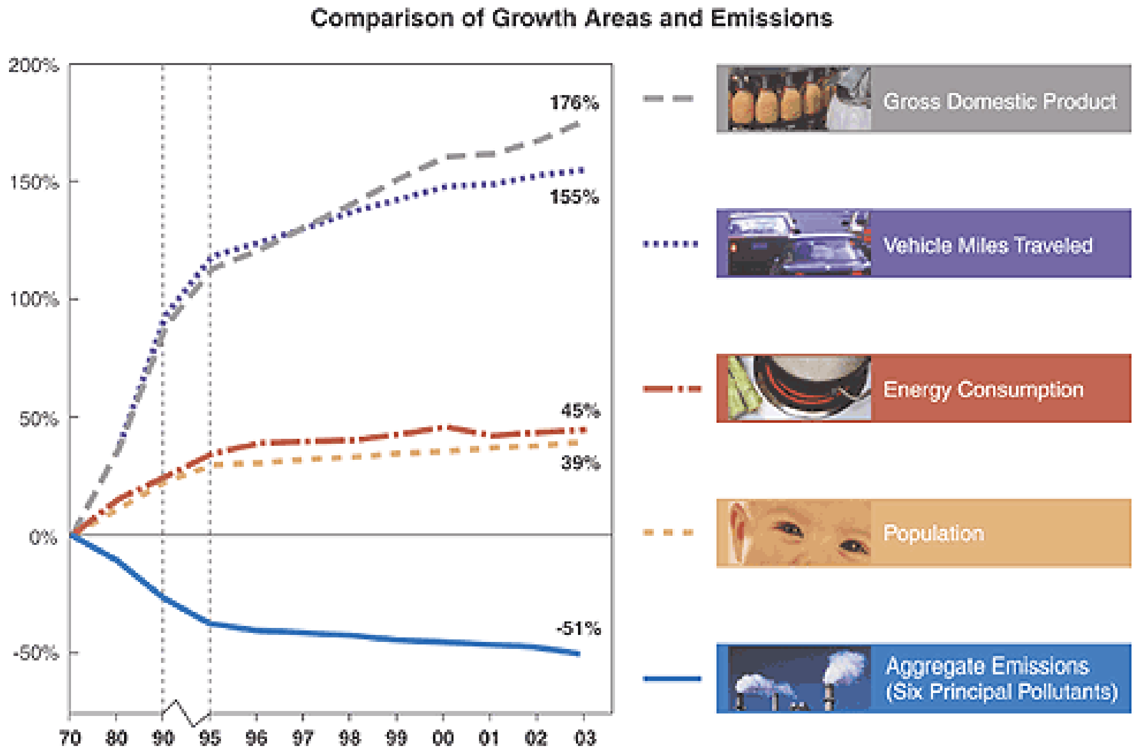
[2] *Heat Advisory*'s Appendix notes that the report uses EPA's 1996 estimate of ozone-forming emissions.

Figure 2. Comparison of Growth with EPA Estimates of Pollution Emissions in the United States since 1970 (EPA, 2003)



Source: EPA 2003.

EPA estimates that between 1996 and 2001 total emissions of NOx and VOC declined, respectively, 10 and 14 percent.[3] EPA has since revised these estimates and extended them through 2002, though this more-recent analysis would not have been available to NRDC at the time it produced *Heat Advisory*. EPA estimates that NOx declined 15 percent between 1996 and 2002, while VOC declined 21 percent.[4]

During 2003 and 2004, EPA implemented ozone-season NOx emissions caps on Midwest and eastern coal-fired power plants and industrial boilers that reduced NOx by 60 percent below 2000 levels during the May-September "ozone season" (EPA 1998a; EPA 2004c). Data from on-road remote sensing, automobile inspection programs, and tunnel studies show that the average NOx emissions rate from automobiles declined about four to nine percent per year between 1995 and 2001, with even greater improvements for vehicles up to four years old (Pokharel, Bishop et al. 2003; Schwartz 2003). Total driving is increasing at less than two percent per year, resulting in large net declines in automobile NOx emissions (Texas Transportation Institute 2004).

Data on heavy-duty diesel vehicles are sparse, but there is every reason to believe diesel NOx has also declined, since EPA has tightened NOx standards for new on- and off-road diesels several times over the last 15 years, and recently engaged in enforcement action against diesel engine manufacturers to reduce NOx from in-use 1993-1998 model year trucks (EPA 2002a; EPA 2004a; EPA undated).

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[3] Data downloaded from http://www.epa.gov/ttn/chief/trends/trends01/trends2001_aug2003.zip.

[4] Data downloaded from http://www.epa.gov/ttn/chief/trends/trends02/trendsreportallpollutants111504.xls.

According to EPA's inventory of NOx emissions, coal-fired power plants and industrial boilers contribute about 25 percent of NOx emissions in the eastern United States, where coal is a major fuel for electricity. A 60 percent reduction in these emissions would amount to a 15 percent reduction in total NOx emissions. Adding this to the 15 percent reduction from 1996 to 2002, NOx emissions have declined at least 30 percent since 1996. This estimate is conservative, as it does not account for NOx reductions from automobiles and diesel vehicles during the last couple of years.

VOC have declined far more than NOx, and far more than EPA's estimates would suggest. EPA's official VOC inventory is known to understate significantly the contribution of gasoline vehicles to total VOC emissions (Watson, Chow et al. 2001). Yet real-world data show the average automobile's VOC emission rate is declining 11 to 15 percent per year, once again much more rapidly than driving is increasing (Pokharel, Bishop et al. 2003; Schwartz 2003). EPA has also implemented VOC reduction requirements for other VOC sources during the last several years (EPA 1998b; EPA 2002c; EPA 2004b).

If we linearly project EPA's estimate of the VOC emissions trend for 1996-2002 out to 2004, we would estimate a 28 percent reduction in VOC from 1996-2004. However, this estimate assumes gasoline vehicles account for only about 40 percent of VOC emissions. If they instead accounted for two-thirds of total VOC and these emissions declined about 11 percent per year, as suggested by real-world field studies (and including growth in total vehicle travel), then total VOC would have declined about 50 percent from 1996-2004.

Thus, NOx and VOC likely declined about 30 and 50 percent, respectively, between 1996 and 2004. By basing its ozone estimates on emissions from 1996, NRDC fails even to provide a reasonable account of current ozone levels, much less future levels. Indeed, *although NRDC claims to have projected ozone levels for 2050, what it in fact did was estimate what ozone levels would have been back in 1996 if the temperature in 1996 had been several degrees warmer and other meteorological variables had stayed the same.*

NRDC actually admits that its ozone estimates are fake within the body of its own report: "Note that this work investigated the effect of changes in climate and not changes in anthropogenic emissions. Thus, the corresponding increases in ozone levels are in response to changes in climate (for example, higher temperatures) rather than changes in anthropogenic emissions (the model accounts for changes in biogenic emissions as a function of temperature). *This research was not intended to provide realistic estimates of future ozone concentrations*, but rather the increase in ozone in direct response to changes in climate, holding anthropogenic emissions constant" (emphasis added).

Despite this qualification in the body of the report, the report's Executive Summary and NRDC's press release on the report claim without qualification that climate change *will* increase future ozone levels. The Executive Summary states "Researchers project under a climate change scenario that by mid-century people living in 15 cities in the eastern United States would see a 60 percent increase—from 12 to almost 20 days per summer—in the average number of days exceeding the health-based 8-hour ozone standard." The press release headline proclaims "Cities' Air Quality Takes a Big Hit as Climate Warms" (NRDC 2004).

Even the sub-title of the report "How Global Warming Causes More Bad Air Days" creates an illusion of guaranteed increases in future ozone levels. NRDC presumably realizes that most readers won't get beyond the Executive Summary and press release. But qualifying these claims in the middle of the main report gives NRDC plausible deniability when more diligent readers point out that the report is deceptive.

NRDC has its analysis backward. Since continued declines in pollution emissions are relatively certain (see discussion below), a sound prediction of future air pollution levels in the presence of climate change would have started with reasonable estimates of future ozone-forming emissions and then projected future ozone levels with and without climate change. Such an analysis would show that ozone will decline in the future regardless of climate change, and would therefore not have served NRDC's goal of creating fear over ostensible future ozone increases.

Already-adopted requirements will eliminate the vast majority of remaining ozone-precursor emissions during the next two decades. EPA tightened emissions standards for automobiles, diesel trucks, and off-road diesel vehicles several times between the late 1980s and 2003 (EPA 2000b; EPA 2000c; Schwartz 2003; EPA 2004a). Most of the benefits of these standards have not yet been realized, as years of fleet turnover will be necessary for higher-emitting earlier models to leave the fleet and thereby clean the air. For example, EPA implemented its "Tier 1" standards for automobiles in the 1994 model year, reducing allowable VOC emissions from 0.4 grams/mile for cars and 0.8 grams/mile for SUVs down to 0.25 grams/mile for all cars and most SUVs, and 0.3 grams/mile for the largest SUVs. The National Low Emission Vehicle (NLEV) program reduced these limits still further starting with the 2000 model year. EPA has implemented progressively tighter limits for both on- and off-road diesel emissions as well.

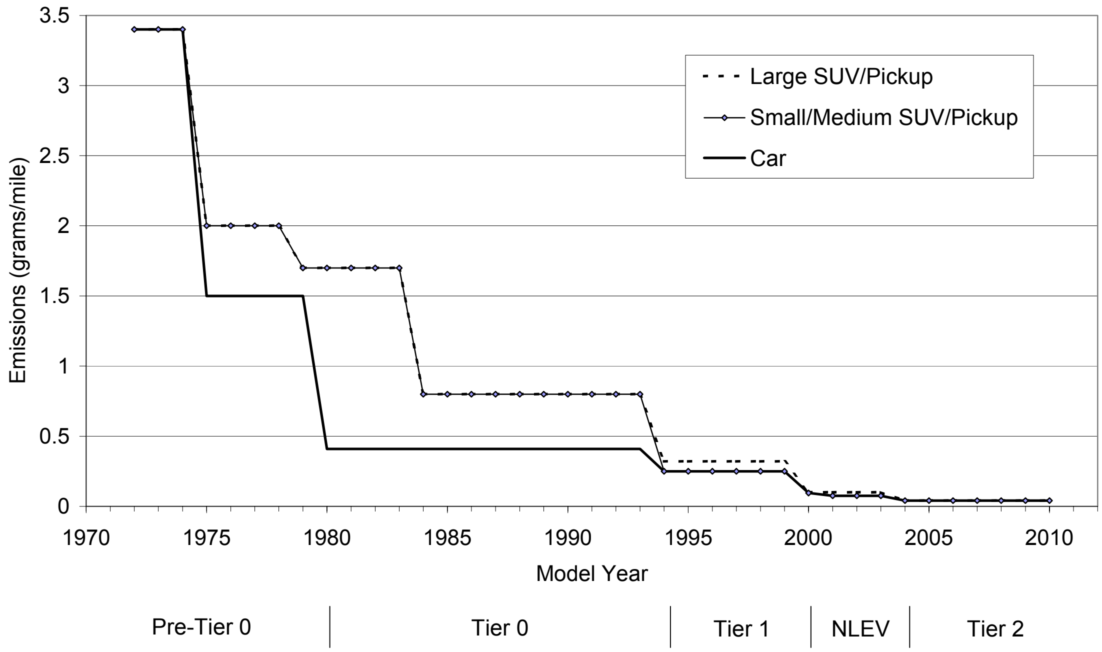
EPA recently adopted tough additional emissions requirements for new automobiles, diesel trucks, and off-road diesel equipment that will reduce NOx and VOC emissions by 70 to 80 percent below previous levels for automobiles, and 90 percent below previous levels for diesel vehicles. These new requirements came into effect in the 2004 model year for automobiles, and will be implemented in 2007 for diesel trucks, and 2010 for off-road diesel equipment (EPA 2000a; EPA 2000c; Schwartz 2003; EPA 2004a).

Figures 3 and 4 show the progressive decline in allowable emissions from automobiles. The automobile fleet takes 15 to 20 years to turn over, but note from the graphs that allowable emissions have been reduced three times in just the last decade. Thus, we have yet to realize the full benefits not only of current standards, but also of standards implemented in 1994 and 2000. Because of these progressive improvements in automobile emissions, the average automobile—cars, SUVs, and pickups—will emit about 90 percent less pollution per mile in 15 or 20 years as the current average vehicle. This ensures huge declines in emissions over the next two decades, even if we do nothing new to reduce vehicle emissions. We can already see these improvements in the real-world. Data from vehicle inspection programs and on-road emissions testing in various cities show that average automobile emissions are dropping 11 to 15 percent per year for VOC and 3 to 9 percent per year for NOx (Pokharel, Bishop et al. 2003; Schwartz 2003). The NOx declines are likely to accelerate in coming years, because NOx regulation lagged several years behind VOC regulation, but has now caught up (see figures 3 and 4).

Growth in driving will do little to offset these gains. For example, if driving increases 80 percent over the next 20 years—a possible increase for a rapidly growing metropolitan area—total automobile emissions will still decline more than 80 percent.[5] Similar arguments apply to diesel vehicles, though the emissions declines will take somewhat longer, due to the longer turnover time for heavy-duty vehicles and equipment.

[5] See this as follows: Assume the average automobile's emissions per mile equal 1.0 today (in arbitrary units). Now assume this emissions rate drops to 0.1 in 20 years, for a 90 percent decline. If total driving increases 80 percent over the same period, total emissions would then be 0.1 * 1.8 = 0.18, for a net decline of 82 percent in ozone-forming emissions, after accounting for both cleaner vehicles and increased driving.

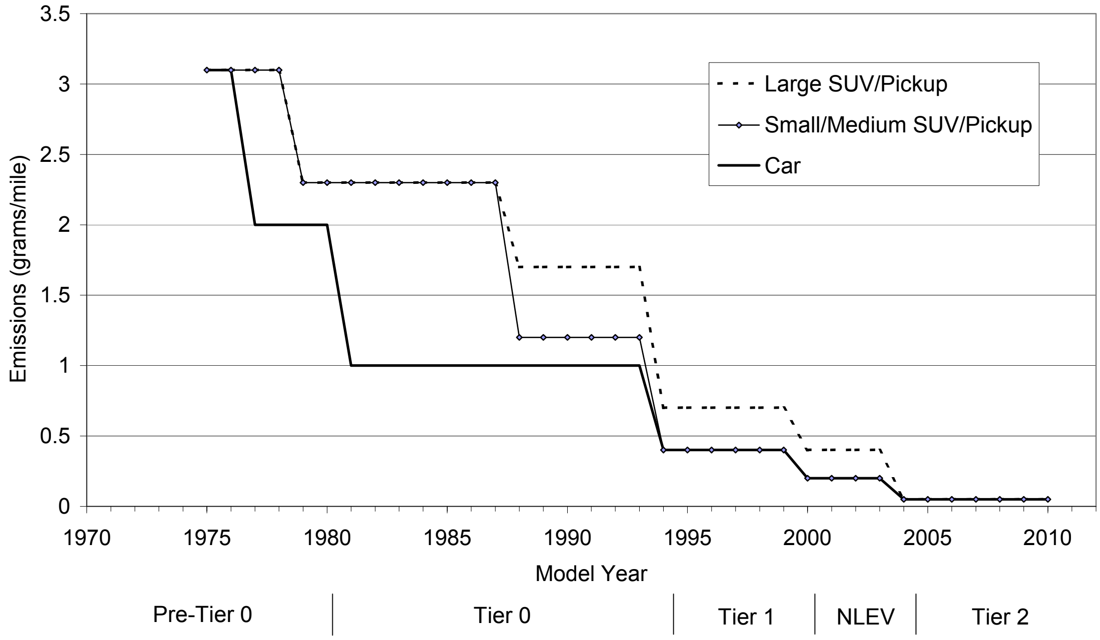
Figure 3. EPA VOC Emissions Standards for New Cars, SUVs, and Pickup Trucks



Notes: In addition to the tougher emissions standards, EPA has also progressively increased the durability requirements for automobiles. Through the 1993 model year, emissions control systems had to meet emissions requirements up to 50,000 miles. From the 1994 to 2003 model years the requirement was extended up to 100,000 miles. For the 2004 model year onward, the requirement is 120,000 miles. NLEV = National Low Emission Vehicle.

Sources: EPA 2000b; Davis and Siegel 2002.

Figure 4. EPA NOx Emissions Standards for New Cars, SUVs, and Pickup Trucks



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Sources: EPA 2000b; Davis and Siegel 2002.

EPA has also progressively reduced industrial emissions. EPA's "NOx SIP Call" regulation recently capped NOx emissions from coal-fired power plants and industrial boilers 60 percent below 2000 levels (EPA 1998a; EPA 2004c). Dozens of other rules continue to reduce NOx and VOC emissions from other industrial sources, from consumer products, and from miscellaneous mobile sources not covered by the motor vehicle regulations discussed above (EPA 1998b; EPA 2002c; EPA 2004b).

Together, these requirements will eliminate the vast majority of remaining air pollution emissions. Future ozone levels will be well below current levels regardless of future climate change. NRDC ignores these guaranteed reductions in future ozone-forming emissions and instead assumes future ozone-forming emissions will be several times greater than one would predict in any plausible scenario. Indeed, by ignoring emission reductions already accomplished between 1996 and 2004, NRDC assumed that NOx and VOC emissions in 2050 will be, respectively, 50 percent and 100 percent higher than they are today.

Increased temperatures will actually cause a net reduction in harm from air pollution, by reducing particulate matter levels more than they increase ozone levels. Increased temperatures lower particulate matter (PM) levels far more than they increase ozone levels. The reason is that about one-third to one-half of all fine particulate matter (PM2.5, the type of greatest regulatory and health concern) is made up of "semi-volatile" nitrates and organic compounds. These compounds evaporate as temperature rises, reducing PM2.5 concentrations.

For example, a recent study of the Los Angeles metropolitan region concluded that, holding ozone-precursor emissions and other variables constant, a nine degree (F) increase in temperature would increase peak ozone by 16 percent and reduce peak fine particulate matter (PM2.5) by 25 percent (Aw and Kleeman 2003). A number of epidemiological studies, particularly the ones cited by EPA and NRDC to support more stringent air pollution regulations, have linked

PM2.5 to more severe health effects than for ozone. Thus, even taking NRDC's warming estimates, as well as its assumption of no change in future pollution emissions, at face value, global warming would actually be expected to result in an overall *reduction* in harm from air pollution.

NRDC cites the same Los Angeles study we cited above, but both misstate and sidestep the PM2.5 results. NRDC claims "Ozone and nonvolatile secondary PM will generally increase at higher temperatures because of increased gas-phase reaction rates. Interannual temperature variability in California, for example, can increase peak O3 [ozone] and 24-hour average PM2.5 by 16 percent and 25 percent, respectively, when other meteorological variables and emissions patterns are held constant."

In fact, the Los Angeles study concluded that, all else equal, higher temperatures increase ozone, but *decrease* PM2.5. The 25 percent figure listed above by NRDC actually represents a *decrease* in PM2.5, rather than an increase. The Los Angeles-Riverside-San Bernardino area, which was the subject of the study, has the highest PM2.5 levels in the country. The study predicted that a nine degree (F) increase in temperature would be associated with about a 30 microgram per cubic meter (ug/m3) decrease in peak PM2.5 in areas of southern California with the highest PM levels.

The study also predicted that substantial ozone increases would occur over a small area, while substantial PM2.5 decreases would occur over a large area. The 16 percent ozone increase mentioned by NRDC was predicted to occur only in a very localized portion (the northwest corner) of the Los Angeles region. The vast majority of the region would experience ozone increases of at most a few percent and many areas would experience no change or even a decrease in ozone. On the other hand, those same higher temperatures were predicted to result in substantial *decreases* in PM2.5—typically 10 to 25 percent—throughout most of the region, while only a small area along the coast might experience an increase of less than one percent. In other words, far more people would benefit from the PM2.5 reductions, than would be harmed by the ozone increases.

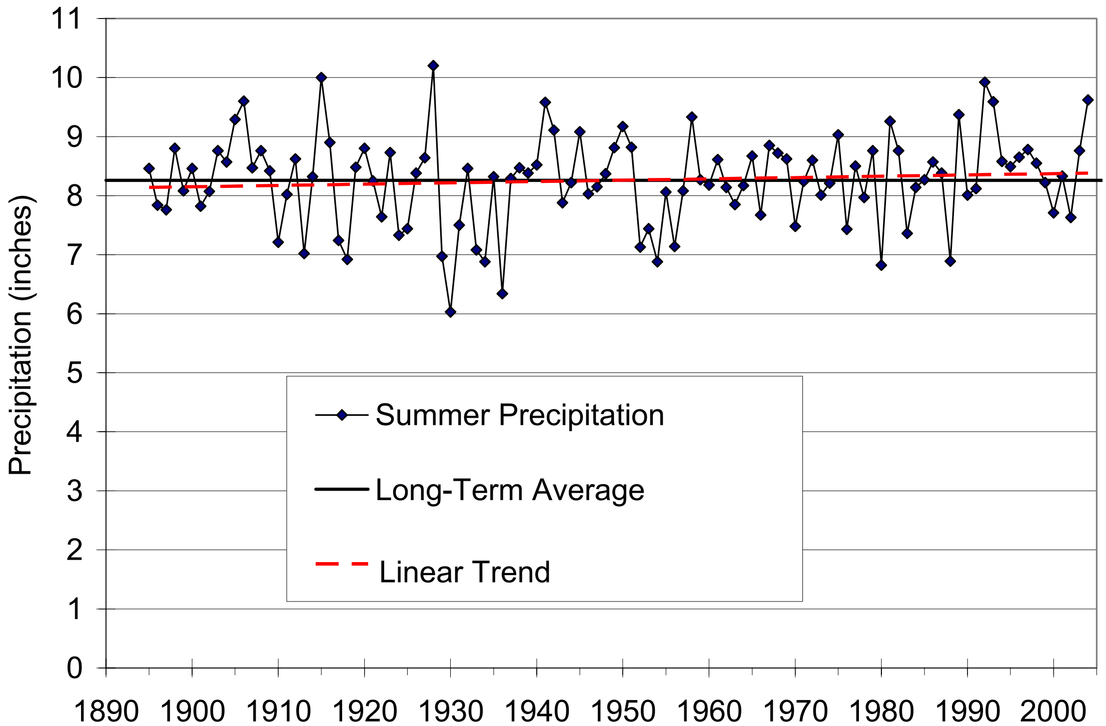
NRDC published *Heat Advisory* out of an ostensible concern for people's health. But taken at face value, the Los Angeles study suggests that the net effect of increasing temperature would be a *decrease in the health effects of air pollution*. This is so for two reasons: First, higher temperatures reduce PM2.5 more than they increase ozone. Second, the conventional wisdom among environmental activists, state and federal regulators, and many epidemiologists is that the health effects of PM2.5 are worse than those of ozone. If NRDC's activists were driven by a genuine concern for people's health one would have expected them to use the Los Angeles study as the basis for a report on how climate change will reduce harm from air pollution.

NRDC's ozone modeling is invalid even for current and past ozone levels. NRDC used MOBILE5b, an outdated version of EPA's computer model for estimating ozone-forming emissions from automobiles and diesel trucks, to feed into a second model used to predict ozone levels in ambient air (Hogrefe, Biswas et al. 2004). MOBILE5b was supplanted by MOBILE6 in January 2002, two-and-a-half years before *Heat Advisory* was published (EPA 2002b). Regardless, both MOBILE5b and MOBILE6, like EPA's overall emissions estimates, have been shown to have substantial accuracy problems, suggesting that NRDC's ozone estimates are invalid even for the 1990s (Robinson, Pierson et al. 1996; Gertler, Sagebiel et al. 1997; Watson, Chow et al. 2001; McClintock 2003; Pollack, Lindhjem et al. 2004).

NRDC says it achieved good agreement between the ozone model results and actual ozone observations. Yet because they fed inaccurate emissions estimates into their ozone model, the good agreement between the model and the observations could easily be due to "model tuning" rather than to a realistic appraisal of the factors contributing to given ozone levels on given days. Tuning refers to the fact that models of pollution formation have numerous adjustable input variables that are set by the researcher. Within the accepted uncertainties, these input variables can be adjusted to get a good fit with the observed data, but the results may have little to do with the real-world phenomena that are ostensibly being modeled (Russell and Dennis 2000). Because NRDC used inaccurate emissions estimates as an input to its ozone model, model tuning is a likely explanation for the good agreement achieved between the model and the observations.

NRDC is selective about which climate changes it assesses for air pollution effects. NRDC assessed only the effect of increased temperature on ozone levels. However, climate models also predict increases in precipitation over much of the United States (according to the National Research Council (2001), "all models project global warming and global increases in precipitation"). Wetter conditions would, all else equal, tend to reduce ozone levels. This would also reduce sulfate and nitrate particulate matter, both due to the direct effect of rain removing airborne particles, and also due to reduced formation of sulfate and nitrate particulate matter, which, like ozone, are formed due to photochemical reactions driven by sunlight. Average precipitation increased in the United States during the last century, and the 1990s was a decade of above-average precipitation, despite increased temperatures, as shown in Figure 5.

Figure 5. Long-Term Trend in Average Summer (June-August) Precipitation in the United States



Source: National Climate Data Center, http://www.ncdc.noaa.gov/oa/climate/research/cag3/na.html.

Actually, in focusing on temperature NRDC did not even pick the climate variable that has the most direct effect on ozone levels. The two most important factors are wind and mixing height—that is, the height to which pollutants can mix upward from the ground. These two factors determine the extent of "ventilation" in a given area. More wind and higher mixing heights mean lower ozone concentrations, and vice versa. Thus, if temperature rises in the future, a key question is how this will affect ventilation around the U.S. For the most part, higher surface temperatures cause a deeper mixed layer and thus better ventilation, although local conditions can vary.

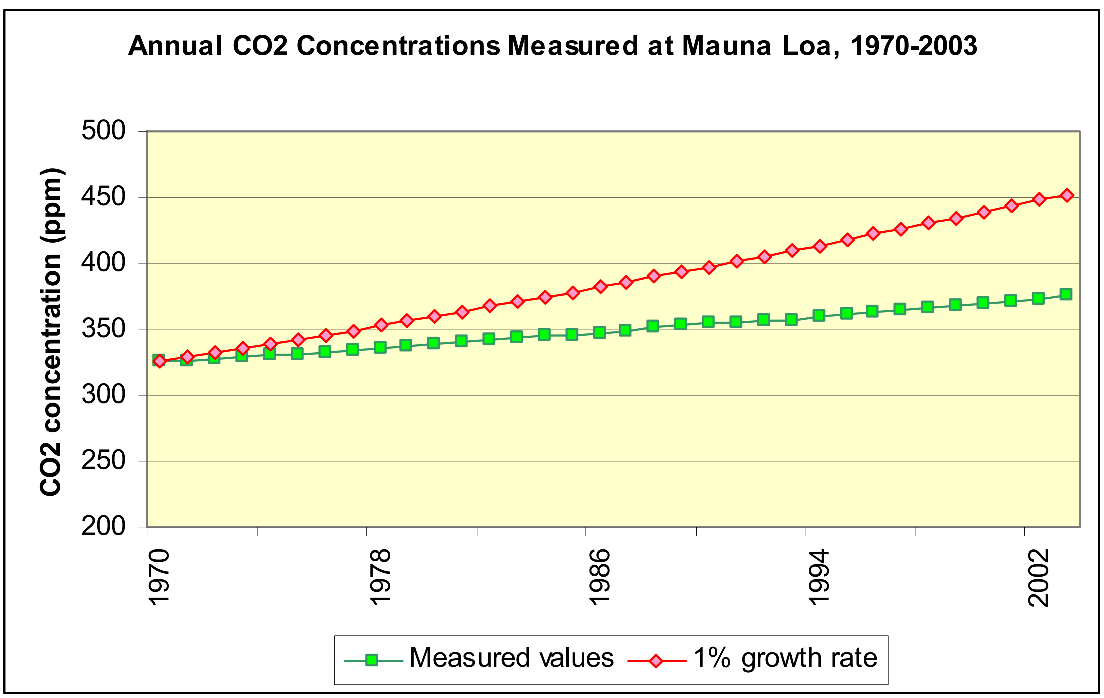
By picking and choosing which potential climate changes to include in their ozone modeling, NRDC was able to manufacture the increases in future ozone levels necessary to support its political goals. But the situation becomes far more muddled when we try to consider *all* the potential effects of a warmer climate on future pollution levels. The spin-off effects of warming could just as well decrease ozone levels.

Of course, as discussed earlier, warmer temperatures will also likely decrease PM2.5 levels, resulting in a net benefit from warming in terms of health effects from air pollution, regardless of the net effect of higher temperatures on ozone levels.

The amount of warming predicted by NRDC is unlikely to occur in any case. Climate models predict linear warming with exponentially increasing greenhouse gas concentrations (see, for example, Figure 7). Thus, temperature trends over the last century should be a starting point to estimate future warming. Based on these trends we would expect average global temperature to rise by less than one degree F by 2100, far less than the roughly 3.5 degrees F increase that NRDC predicts even for 2050.[6] Warming over the U.S. during the summer "ozone season" would be even less than this, because these same climate models predict most of the warming would occur in Polar Regions, during the winter, and at night (Polyakov et al. (2002) address this in their report, and it is a fundamental conclusion of all climate model projections).

The extreme warming predicted by NRDC required several extreme assumptions, including unrealistically high population growth, little change in energy or transportation technology, and a disregard for factors which would serve to lessen or reverse any possible warming, such as increased cloud cover. For example, the scenario used by NRDC assumes a one percent per year increase in the amount of CO2 in the atmosphere. However, during the last three decades, atmospheric CO2 has been rising at less than half that rate (see Figure 6).

Figure 6. Actual CO2 concentrations measured at Mauna Loa, compared with a 1% growth rate

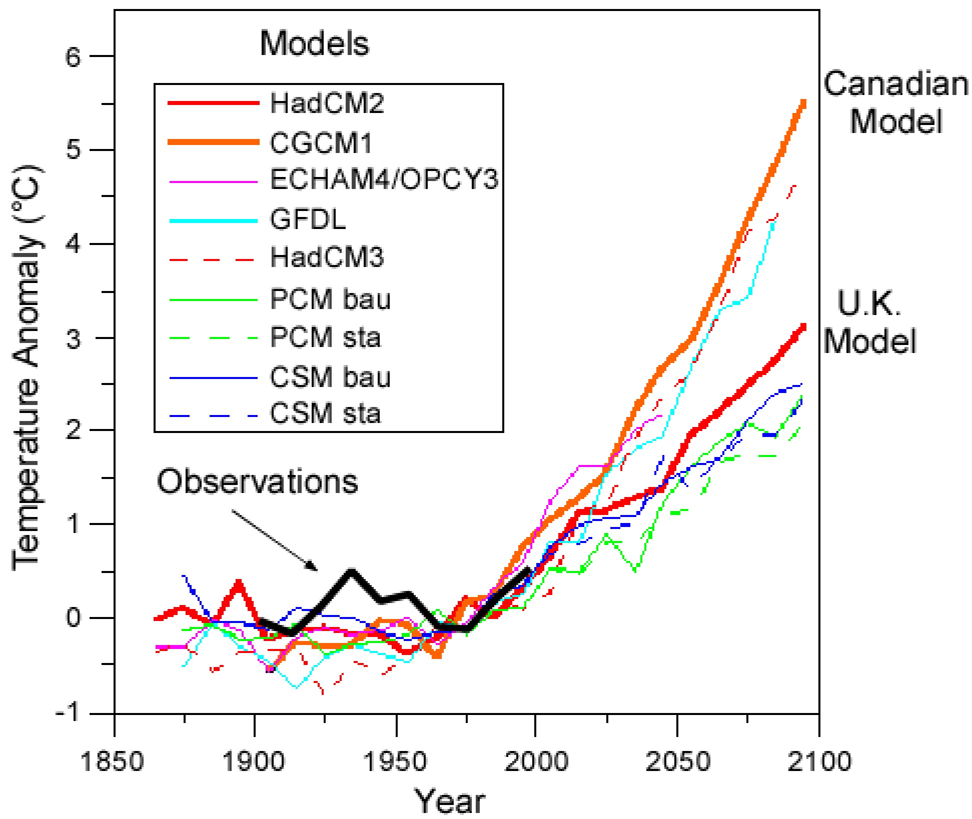


Source: Carbon Dioxide Information Analysis Center 2004.

[6] 20th Century temperature trends were obtained from the Goddard Institute for Space Studies web site, http://www.giss.nasa.gov/data/update/gistemp/graphs.

Figure 7 shows the observed U.S. annual temperature trends during the 20th Century along with model projections from the U.S. National Assessment. Note that the models predict a large increase in the slope of temperature vs. time. This unrealistically large slope is due to the assumption of much larger CO2 emissions than have been or are actually occurring, while disregarding natural variations due to solar, oceanic, volcanic, and other variations in the Earth's system known to affect climate. The models are also unable to account for the significant warming (the greatest of the last century) from 1920 to 1940, which was greater than late 20th Century warming.

Figure 7. The past and future temperature history of the United States as forecast by the climate models considered for inclusion in the US National Assessment.



Notes: The two models chosen as the basis for the assessment of the impacts of future climate change in the United States are the Canadian model and the U.K. model. The Canadian model predicts the most warming of any of the models reviewed (see www.co2andclimate.org/climate/previous_issues/vol6/v6n20/assess1.htm).

Toward a more plausible assessment of climate change and air pollution. *Heat Advisory*'s assessment of climate change and future air pollution starts with a projection of future temperature and then applies an estimate of *past* ozone-forming emissions to project *future* ozone levels. This is both backwards and incomplete. A defensible analysis would start with plausible projections of both future ozone-forming emissions and CO2 emissions and then compare ambient pollution levels with and without predicted climate change. This would isolate the effect of future climate change on future pollution levels. To make this a complete assessment, it should include not only temperature and ozone, but other climate variables and other pollutants of concern. Key climate variables would include wind, mixing depth (the vertical extent to which ground-level air and emissions can mix upward), and frequency of precipitation. Particulate matter should be assessed in addition to ozone to ensure that the *overall* effects of climate change on air pollution are assessed.

What would be the results of such an analysis? Given that ozone-forming emissions will decline at least 80 percent over the next few decades, ozone will decline substantially with or without a warming climate, but the decline might be smaller in a warming climate. We say “might,” because the net effect of other climate variables, such as precipitation, is unclear and could offset the ozone-increasing effect of temperature increases alone.

PM2.5 levels will also decline substantially with or without warming, and the *decline is likely to be greater in a warming climate*. Warming is likely to reduce PM2.5 on net, because the direct effect of temperature on PM2.5 is much larger than its effect on ozone, making it unlikely that any PM2.5-increasing effects of other potential climate changes could offset the PM2.5-reducing effect of higher temperatures.

Detailed Critique of *Heat Advisory*

Below are some direct quotes from the NRDC report, followed by our responses. The NRDC statements are shown in *italics.*

"As global warming causes hot summer days to get hotter"

Climate models suggest that the bulk of warming in a greenhouse-warmed world will occur in the high latitudes, in winter, and at night; this is due to the fact that only in the driest air on the planet (which is also the coldest) will water vapor be in scarce enough supply to make carbon dioxide and methane anything more than minor greenhouse gases (water vapor is by far the most important greenhouse gas). Polyakov et al. (2002) address this in their report, and it is a well-known aspect of greenhouse physics. Summer daytime temperatures in the United States should be minimally affected by any enhanced greenhouse warming that may occur.

"What happens if global warming brings hotter and dryer summers over much of the United States?"

This is speculative and the opposite of the expected net effect of climate change. Climate models suggest that the greatest warming in a greenhouse-enhanced world should come at night, in winter, and toward the poles. The general trend is expected to be towards wetter, not drier, conditions (National Research Council 2001). Regionally, there will be variations – some places will probably be wetter and some drier in the future – but regional climate change cannot be modeled with any degree of certainty. To the extent that increased temperatures are accompanied by increased rainfall, ozone would be expected to decline.

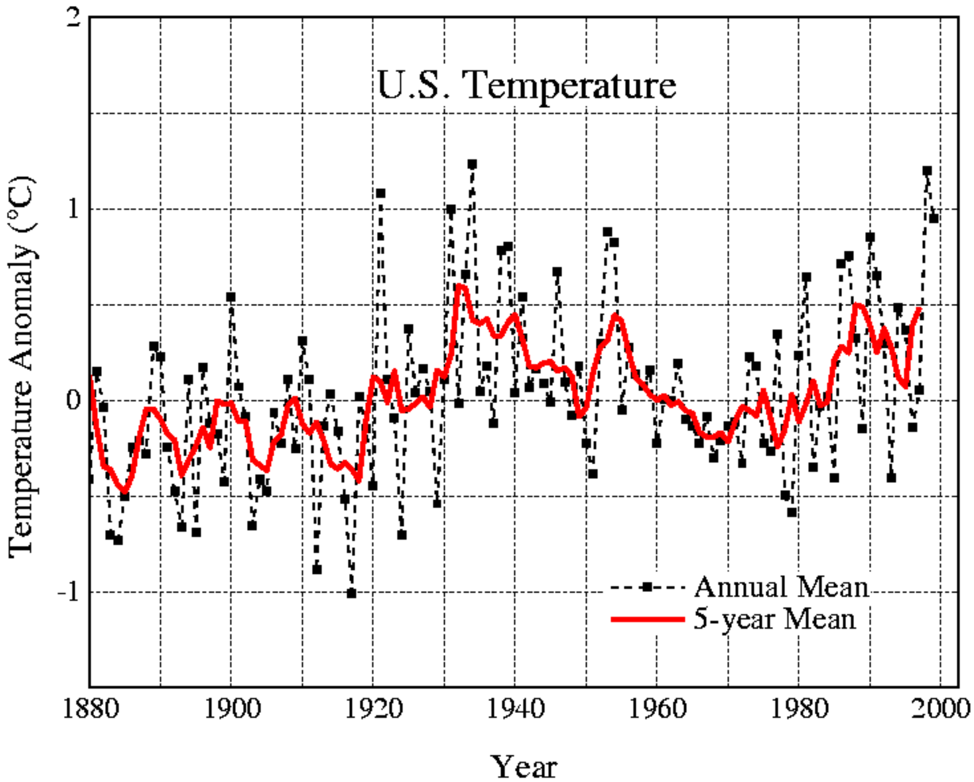
"Large high-pressure systems often create a temperature inversion, trapping pollutants in the boundary layer at the earth's surface. It has been suggested that with climate change we are likely to see more instances of very hot weather combined with increases in air-pollutant concentrations."

If greenhouse-enhanced warming does occur, the most significant increases in temperature will be at night and in winter. Summer daytime increases will be minimal. The effects on daytime warm-season pollutants, such as ozone, will also therefore be negligible.

"Since the late 1950s, the global average surface temperature has increased by 1 degree Fahrenheit. Snow cover and ice extent have diminished."

This is generally true. But the 1950s were a rather cold decade and the beginning of a 25-year period of declining temperatures (which triggered fears of a "coming ice age" in the 1970s, along with a series of alarmist books and reports on the subject). We can see that NRDC carefully selected its base year (1950) if we go back a bit further in time. Figure 8 shows temperatures in the United States since 1880. Note the general increase in temperatures in the last 40 years. But note also that the warmest decade in the last 120 years was the 1930s. These conditions preceded the "greenhouse gas enhancement" which began in earnest during and after World War II. Likewise, snow cover and glacial ice have been declining since the mid-1800s, when the Earth came out of the "little ice age." The Earth has been warming and sea level has been rising since at least the mid-1800s, even though humans did not add significant amounts of greenhouse gases to the atmosphere until after 1940.

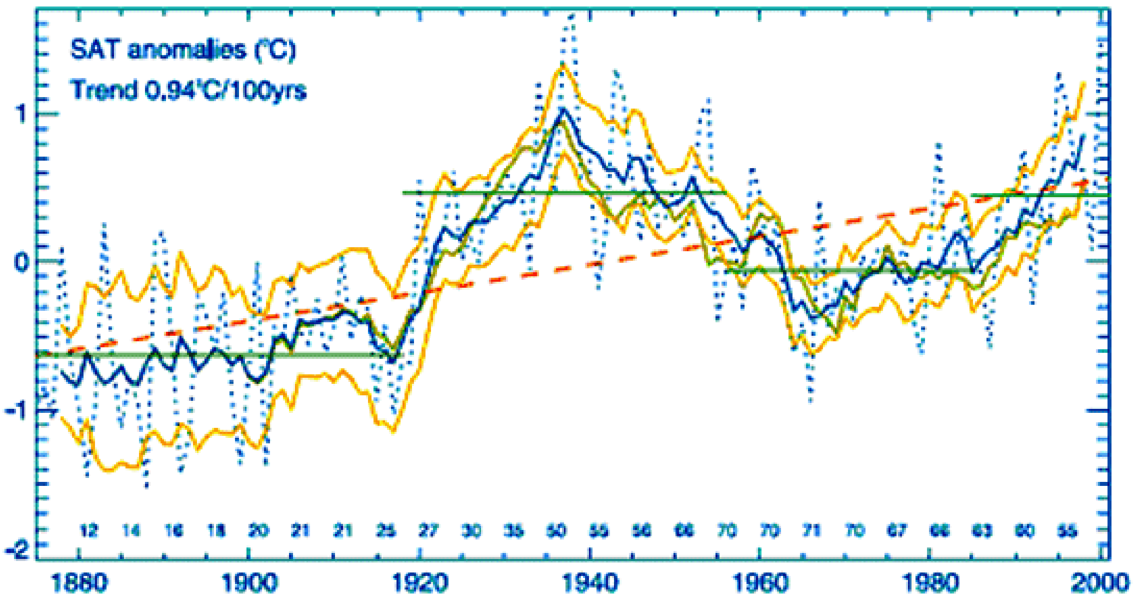
Figure 8. US National Average Temperature, 1880- 1999



Source: Goddard Institute of Space Studies, http://www.giss.nasa.gov/research/intro/hansen_07/.

The trends above were by no means restricted to the United States. Figure 9 shows temperatures in the Arctic (where greenhouse enhancement would be expected to be the greatest) over the same period. The results are similar to the U.S. The 1930s was the warmest decade in the last 120 years, and this warm spell occurred before humans had added significant amounts of CO2 to the atmosphere.

Figure 9. Surface Air Temperature Anomalies in the Arctic, 1880-1999



Notes: The vertical axis gives the difference in each year's temperature (in degrees (C)) from the long-term average.

Source: Polyakov, Akasofu et al. 2002. Graphic obtained from http://www.greeningearthsociety.org/wca/2004/wca_27b.html.

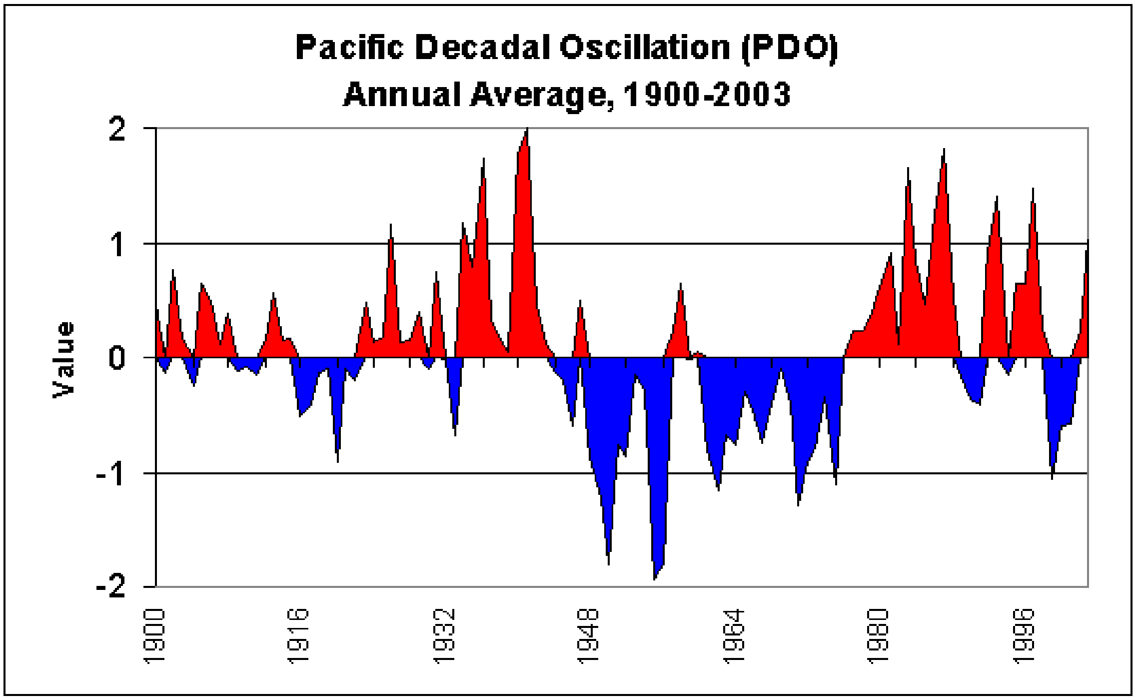
"Although natural climate variability may play a role in these changes, it cannot explain the magnitude, rate, and pattern of the changes."

If this were true, how would one explain the increase in temperatures from 1920 to 1940, before humans had added significant amounts of greenhouse gases to the atmosphere? How can one explain the strong correlation between the Pacific Decadal Oscillation (PDO) and global temperatures? Or the correlation observed between variations in solar radiation and variations in global temperatures? How can one explain the fact that the northern hemisphere seems to be warming faster than the southern, even though greenhouse physics says it should be the other way around (see, for example, Christy and Norris (2004).

The PDO is a long-lived El Niño-like pattern of Pacific climate variability. The PDO represents the trends in Pacific sea surface temperatures over timescales of several decades. The PDO is one of the dominant modes of variability in US and global temperatures. Higgins et al. (2002) studied winter-spring temperatures in the US since 1950, and concluded that there was considerable decadal variability. Gedalof and Smith (2001) analyzed climate over the last 400 years in the Pacific Northwest, British Columbia, and Alaska by studying tree rings from mountain hemlock. They concluded that "much of the pre-instrumental record in the Pacific Northwest region of North America is characterized by alternating regimes of relatively warmer and cooler SST [sea surface temperature] in the North Pacific, punctuated by abrupt shifts in the mean background state." They found that "regime shifts in the North Pacific have occurred 11 times since 1650" and that "another regime-scale shift in the North Pacific is almost certainly imminent."

Figure 10 shows annual PDO values since 1900. Note how the warm 1930s, 1980s, and 1990s were characterized by positive PDOs and the much cooler 1950s through early 1970s by negative values. Positive PDOs are periods with more frequent and stronger El Niño events, which lead to generally warmer conditions, while negative PDOs are linked to cooler periods due to a preponderance of La Niña events. The climate record of the last hundred years thus clearly shows that natural variability can cause large short-term variability in various aspects of the Earth's climate.

Figure 10. Pacific Decadal Oscillation (PDO) annual averages



Source: Mantua 2004.

"CO2 concentrations are projected to rise to 600–720 ppmv by the end of the 21st century."

This claim is based on one of the assumptions made for the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Figure 6 (above) shows actual CO_2 trends measured at Mauna Loa, compared with a one percent growth rate. The average rate of increase is about 0.4 percent per year, which, if it were to continue for 100 years, would raise CO_2 to about 550 ppm.

"Researchers project under a climate change scenario that by mid-century people living in 15 cities in the eastern United States would see a 60 percent increase—from 12 to almost 20 days per summer—in the average number of days exceeding the health-based 8-hour ozone standard established by the U.S. Environmental Protection Agency (EPA) (see Figure ES-1). The number of unhealthy 'red alert' days would double. Correspondingly, these citizens would enjoy, on average, nearly 20 percent fewer healthy air days in future summers because of global warming."

As shown in Section II above, despite increasing urban temperatures, during the last 30 years the average number of "red alert" days (1-hour ozone exceedances) per year declined 95 percent in the U.S., while the average number of "orange alert" days (8-hour ozone exceedances) declined 75 percent. Most ozone monitoring locations now have zero red alert days and fewer than 10 percent of locations average more than one per year. The 60 percent increase in 8-hour ozone exceedances generated by NRDC requires both unrealistically large future temperature increases, along with ozone-forming emissions several times greater than will actually occur. In fact, NRDC assumed ozone-forming emissions in the future will be about 75 percent greater than ozone-forming emissions today, despite the fact that emissions have been decreasing, and already-adopted requirements will eliminate most remaining emissions.

"Future air pollution control strategies should address heat-trapping pollution, such as carbon dioxide, as well as the pollutants that are direct precursors to ozone."

This statement, in the Executive Summary, makes it seem as if there haven't been any efforts to address future emissions of ozone precursors. In reality, already-adopted actions will eliminate most remaining ozone-forming pollution over the next 20 years or so—long before climate change, should it occur, would significantly affect average temperatures (see detailed discussion in Section II). Furthermore, higher temperatures reduce fine particulate matter (PM2.5) more than they increase ozone. As a result, whatever the health effects of current levels of air pollution, climate change would be expected to, on net, *reduce* air pollution's health effects rather than increase them.

"More than 100 million Americans currently live in counties that do not comply with health based air quality standards for ground-level ozone, commonly known as smog."

This is a great exaggeration. For the record, about 16 million Americans live in areas that violate EPA's old 1-hour ozone standard and 75 million live in areas that violate the tougher new 8-hour ozone standard (Schwartz, Hayward et al. In press). NRDC's claim is for the 8-hour standard, and it makes the unrealistic assumption (as does EPA) that everyone in a county classified as "non-attainment" for ozone experiences ozone levels that violate the 8-hour standard. However, EPA classifies whole counties as non-attainment even if only one monitoring location violates the standard. This makes sense for air quality planning, because emissions in one area can affect ozone levels in another. But it has nothing to do with ozone levels people actually experience, because many counties have large areas that comply with the 8-hour standard. For example, 99 percent of people in San Diego County, 95 percent in Cook (Chicago) and Maricopa (Phoenix) counties, and 60 percent in Los Angeles County live in areas that comply with both the 1-hour and 8-hour ozone standards, yet NRDC (and EPA) count all 21 million of these people as living in areas that violate the 8-hour ozone standard (Schwartz, Hayward et al. In press).

"Ozone levels are more sensitive to temperature and weather than other air pollutants, suggesting that global warming could worsen the health risks from ozone. Rising temperatures across the eastern United States will increase smog, and this in turn could mean more hospital admissions from respiratory illnesses such as asthma."

PM2.5 levels are as or more sensitive to temperature than ozone. A modeling study for Los Angeles concluded that, all else equal, a nine-degree (F) increase in temperature would be associated with a 16 percent increase in peak ozone and a 25 percent decrease in peak PM2.5 (Aw and Kleeman 2003). Furthermore, increased temperatures were associated with large ozone increases only in a localized area of the Los Angeles region, but with large PM2.5 declines over most of the region. To the extent that current levels of air pollution are causing hospital admissions, we would expect global warming to result in a net *decrease* in air-pollution-related hospital admissions and other air pollution-related health effects, both because PM2.5 would undergo larger and more widespread absolute declines when compared with ozone increases and because PM2.5 is more strongly associated with health effects than ozone in epidemiological studies.

"Higher smog levels trigger asthma attacks and make it difficult to breathe, particularly for children and the elderly."

Categorical statements like this make it seem as if any increase in ozone causes serious harm to huge numbers of people. In fact, few people are affected by air pollution and the effects are rarely serious. For example, when EPA created the 8-hour ozone standard in 1996, the agency predicted that going from full attainment of the old 1-hour standard to full attainment of the new 8-hour standard would reduce hospitalizations for asthma attacks by 0.6 percent, even though the 8-hour standard is significantly more stringent (EPA 1996). Data from around the U.S. show that hospitalizations for asthma are lowest in July and August, when ozone levels are at their highest (Spokane Regional Health District 2002; Tippy and Sonnenfeld 2002; Gent, Triche et al. 2003; Stockman, Shaikh et al. 2003; Texas Department of Health 2003; Wilcox and Hogan undated). This summer minimum in asthma hospitalizations would be impossible if ozone was a significant cause of asthma hospitalizations or other respiratory distress related to asthma.

"There is some recent evidence that ozone triggers and worsens asthma attacks. In fact, recent data suggest that even at low levels of ambient ozone (and controlling for ambient fine particle concentration), children with severe asthma using maintenance medication are particularly vulnerable to O_3 and are at a significantly increased risk of experiencing respiratory symptoms. The researchers found that O_3 was significantly associated with respiratory symptoms and the use of rescue medication among those using maintenance medications. A 50 ppb increase in O_3 corresponded to a 35 percent increase in self-reported wheezing and a 47 percent increase in those reporting chest tightness."

NRDC refers to a study of air pollution and asthma symptoms among children in Connecticut and Massachusetts (Gent, Triche et al. 2003). Increases of 35 and 47 percent sound like big effects. But a bit of context shows that even among children with serious asthma, this study suggests that few children experience asthma symptoms as a result of ozone. We begin by looking at the baseline rate of asthma symptoms. Children with serious asthma—those using maintenance medication—experienced a baseline rate of wheezing on 2.8 percent of days, and chest tightness on 1.2 percent of days.[7] Thus, on a day when 1-hour ozone jumped 50 parts per billion (ppb), we would expect the risk of wheezing to rise 35 percent from 2.8 to 3.8 percent and the risk of chest tightness to rise 47 percent from 1.2 to 1.8 percent.

In other words, the baseline symptom rates are low to begin with, so even with a large percentage increase the frequency of asthma symptoms remains relatively low. For example, in this case a 50 ppb ozone rise would mean that among children with serious asthma, we'd go from 1-in-36 children experiencing wheezing up to 1-in-26 experiencing wheezing on any given day. NRDC gives the impression that virtually all children with serious asthma experience asthma

[7] These were the median rates reported in the study.

symptoms on high-ozone days. In fact, asthma symptoms are relatively rare, despite ozone increases. And note that this same study reported that children with milder asthma—those not on maintenance medication—experienced no increase in symptoms at any ozone level.

High-ozone days are also relatively infrequent, so the overall effect of ozone in any given year is relatively small. For example, we can ask how much we should expect asthma symptoms to decline due to reductions in ozone. Based on data presented in the study report, the study region experienced the equivalent of roughly 40 days during the 180-day study period when 1-hour ozone rose 50 ppb above the summertime background level of about 50 ppb.[8] How much would overall asthma symptoms among medication users go down if these ozone increases were completely eliminated? The risk of wheezing would drop from 2.80 percent to 2.69 percent, while the risk of chest tightness would drop from 1.80 percent to 1.71 percent. In other words, large reductions in ozone would result in small changes in overall asthma symptoms.

Note that this is the reduction in asthma symptoms we would expect from reducing ozone from current levels down to background levels—roughly an 11 ppb decrease in average daily 1-hour peak ozone levels during the warmest six months of the year.[9] NRDC predicts that climate change would increase summer average 1-hour ozone levels by about 4 ppb in 2050. So the study NRDC cites to give the impression that climate change will cause substantial increases in harm to asthmatics in fact shows that even if climate change does increase ozone levels, it would have almost no effect on the health of asthmatics.

Asthma can be a serious and frightening disease, and nobody wants to see children or anyone suffering from it. The point isn't whether it would be good to reduce the harm from asthma. Of course it would. But taking NRDC's results at face value, climate change would increase asthma symptoms by one-twentieth of a percentage point. Is this really what we should be worrying about if we want to improve children's respiratory health? Of course, in reality, as shown in Section II, ozone will continue to decrease regardless of future climate change.

Another wrinkle in this welfare calculus is that the Connecticut/Massachusetts asthma study isn't necessarily definitive and the associations it reports might not represent a real cause-effect relationship between ozone increases and asthma symptoms. For example, the study's results applied mainly to 1-hour ozone levels. 8-hour ozone levels, which were the focus of NRDC's report, were more weakly or not at all associated with asthma symptoms. The U.S. has been most successful in reducing 1-hour ozone levels, while 8-hour levels have declined more slowly.

Technical aspects of the study's statistical analysis are also questionable. For example, the children in the study came from wide range of areas in Connecticut and western Massachusetts, but the researchers assigned a single pollution level to all of them. Instead of using the nearest pollution monitor to represent exposure for a given child, the researchers averaged pollution levels at all monitors, which were spread over a few thousand square miles.

The researchers used a statistical model that inadequately controlled for weather. For example, the model included only same-day weather, but not previous-day weather, and temperature was the only weather variable in the model, even though other factors, such as humidity, might affect asthma symptoms. The study also did not control for day of week and season, which could confound the results. For example, asthma symptoms rise in September in many areas, independent of pollution levels (Spokane Regional Health District 2002; Tippy and Sonnenfeld 2002; Gent, Triche et al. 2003; Wilcox and Hogan undated).

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[8] Of course, some days had smaller rises and a few had larger ones. For simplicity, we've simply converted these to the number of "50 ppb equivalent" days.

[9] 40/180 days * 50 ppb ozone = 11 ppb reduction on an average day.

Thus, when thinking about how to reduce the burden of diseases like asthma, we need to worry not only about what interventions will provide the most bang for the buck, but how certain we are that a given intervention will confer the desired benefits. NRDC ignores the real-world implications of the studies it cites, and appears instead to be focused on how to cherry-pick and structure information so as to create unwarranted scares about air pollution and climate change.

"It is also possible that ozone air pollution may actually lead to the development of asthma in children, as opposed to simply exacerbating existing disease. Controlling for the level of activity in children playing after-school sports, the relative risk of developing asthma was 3.3 times as high in communities with high ozone as in communities with low ozone."

NRDC misreports the results of this study. First, only children who played three or more team sports (8 percent of all children in the study) were more likely to develop asthma, rather than all "children playing after-school sports" as NRDC claims (McConnell, Berhane et al. 2002). Second, and more importantly, NRDC fails to mention that this same study reported that when looking at the entire sample of children, the asthma rate was 30 percent *lower* in areas with *higher ozone*.

Third, the high-ozone areas in this study averaged 50 days per year exceeding the 1-hour ozone standard and 80 days per year exceeding the 8-hour standard during 1994-97 when the study was performed. No area outside California has ever come close to these ozone levels, so the study is not applicable outside the high-ozone areas of California. In fact, the study is not even applicable within California either, because ozone levels have dropped there as well. The worst area in California (Crestline) now averages about 20 to 30 1-hour ozone exceedances per year, or about half the level in the worst areas assessed when the study was performed.

Appendix: Trends in Ozone and Temperature in Various Metropolitan Areas

This appendix includes graphs of the trend in 8-hour and 1-hour ozone exceedance days per year and summer temperatures in 19 metropolitan areas. We've included the same 15 areas included in NRDC's *Heat Advisory* report, as well as four additional areas: Boston and New York, because they are large eastern metropolitan areas not discussed by NRDC, and Houston and Los Angeles, because they are known for their relatively high ozone levels.

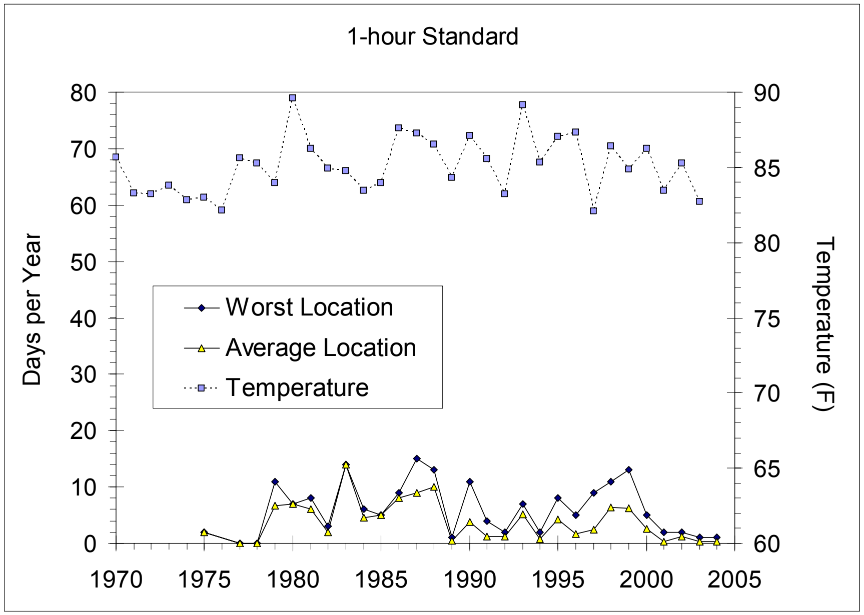
Figure 11. Ozone and Temperature Trends in 19 Metropolitan Areas

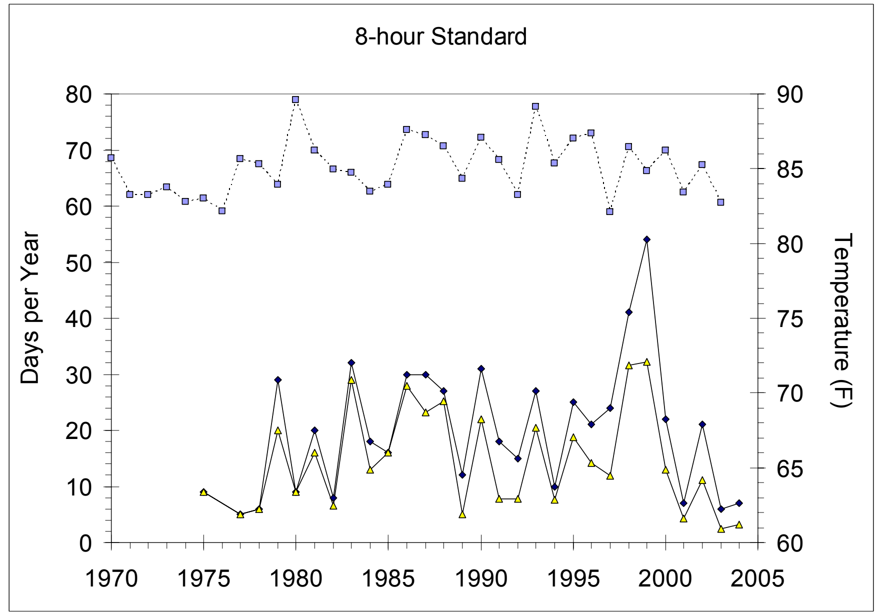
Notes: There are two graphs for each metropolitan area. The left panel is the trend in 1-hour ozone exceedance days per year at the worst and average site in the given metropolitan area, while the right panel provides the trend in 8-hour ozone exceedances. The 1-hour ozone standard is exceeded when the highest 1-hour average ozone level measured on a given day reaches or exceeds 0.125 parts per million (ppm). The 8-hour standard is exceeded when the highest 8-hour average ozone level measured on a given day reaches or exceeds 0.085 ppm. Because of the different averaging periods, the standards are not directly comparable. However, the 1-hour standard is roughly equivalent to an 8-hour standard set at 0.095 ppm. In other words, the 8-hour standard is *more stringent* then the 1-hour standard. Thus, in the graphs below you will note that all areas exceed the 8-hour standard more frequently than the 1-hour standard.

All monitoring sites operating in a given year are included. Each panel also includes a temperature trend. Temperature is given as the average of daily peak temperatures from May through September of each year. The left vertical axis gives the number of exceedance days per year and is on the same scale in all graphs except for Los Angeles, which has far more ozone exceedances than the rest of the country and requires a larger vertical scale. The temperature range varies from city to city, so temperatures are on different scales. However, the range is always 30 degrees across the scale, which means that temperature variation from year to year, as well as long-term trends, can be directly compared across different cities.

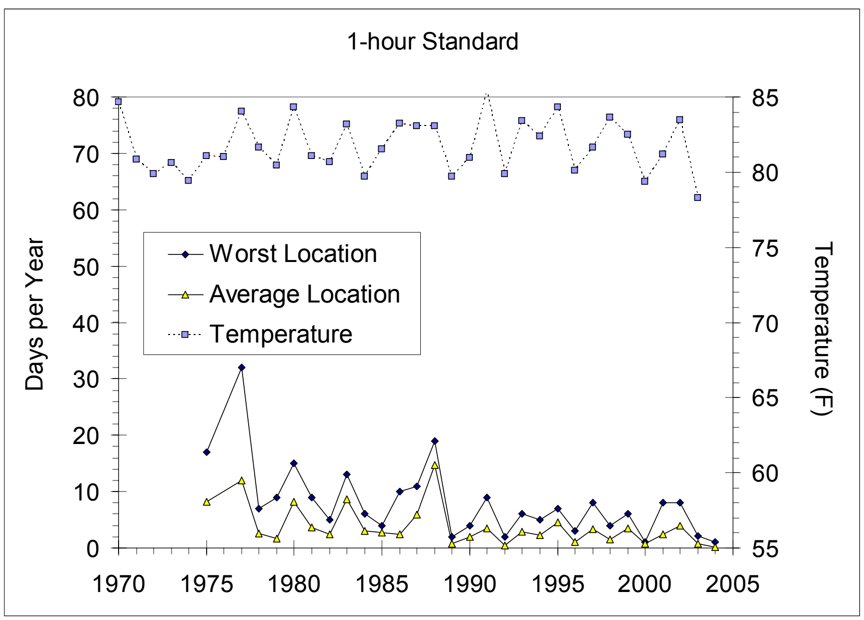
Data sources: Ozone data were downloaded from EPA's AQS pollution monitoring database, http://www.epa.gov/air/data/index.html, except for 2003 and 2004 California data, which were downloaded from http://www.arb.ca.gov/aqmis2/annual_ozone.php. Temperature data were downloaded from the National Climatic Data Center, http://www.ncdc.noaa.gov/oa/ncdc.html.

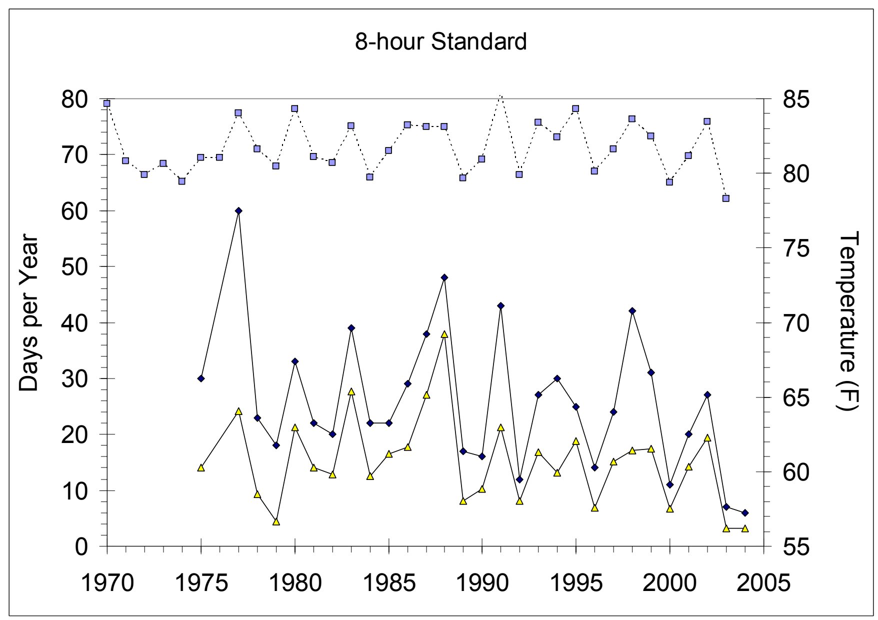
Atlanta



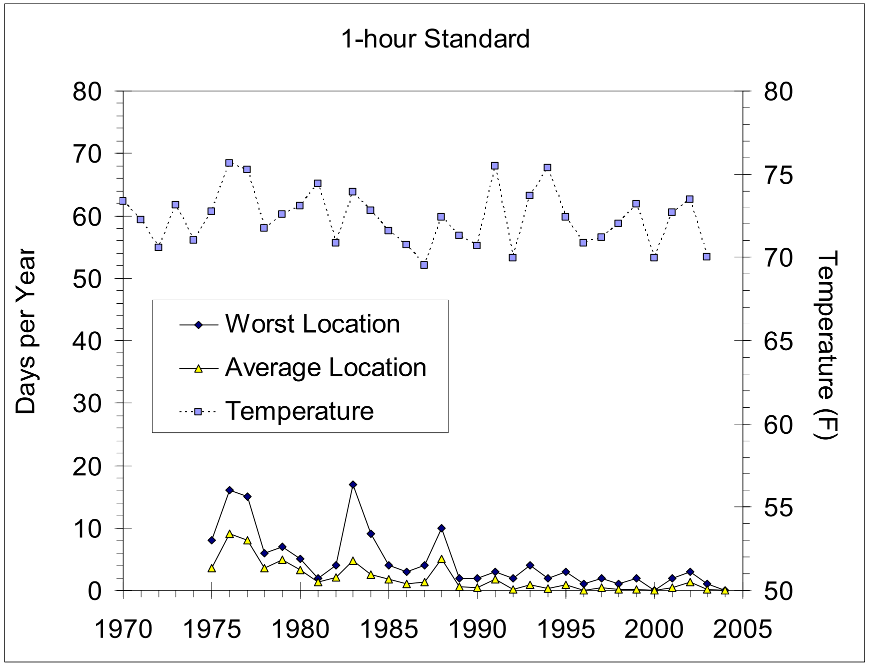


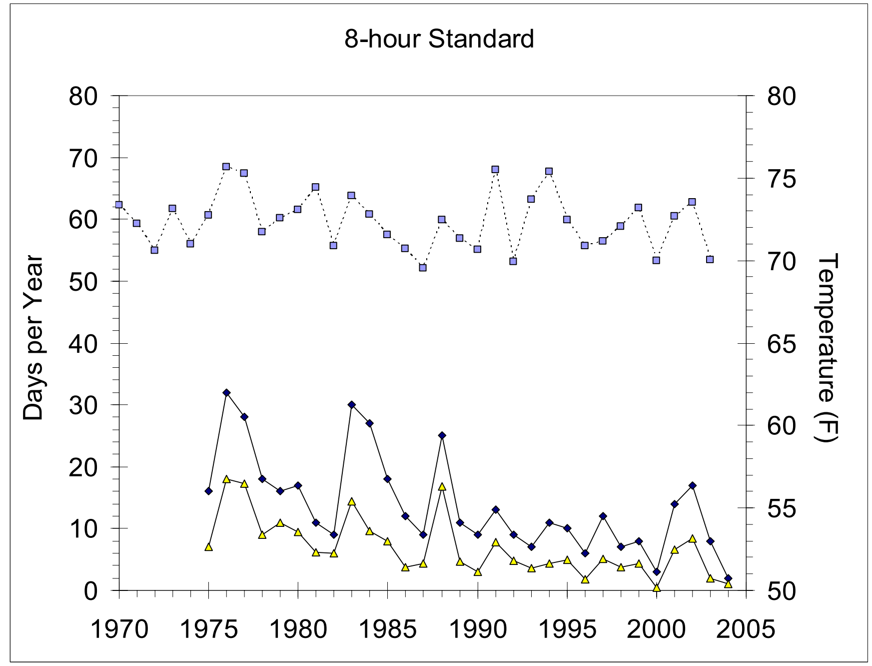
Baltimore



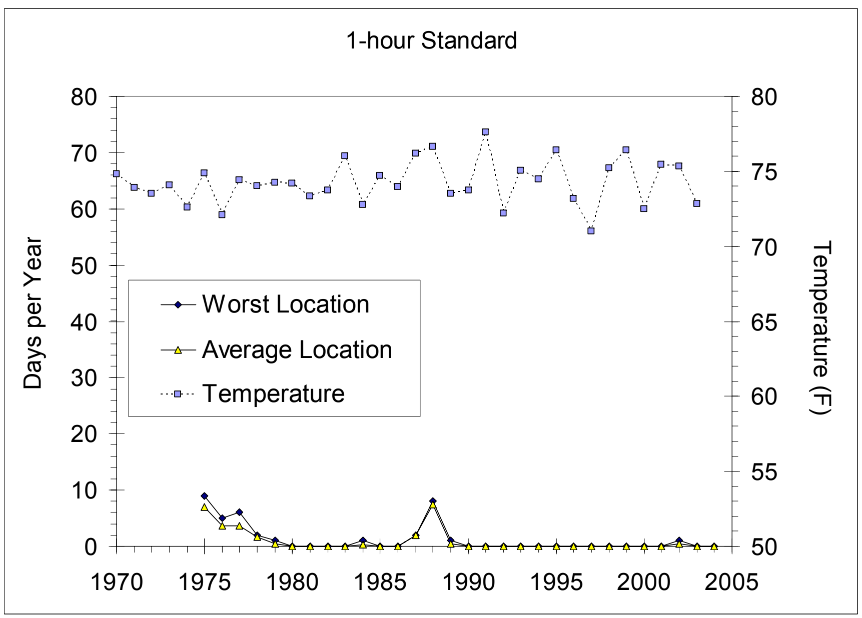


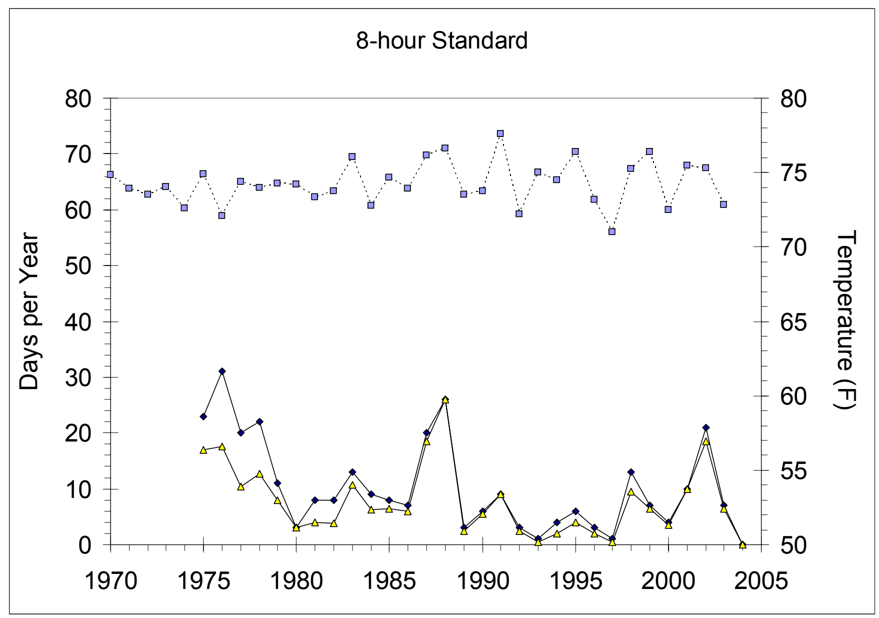
Boston



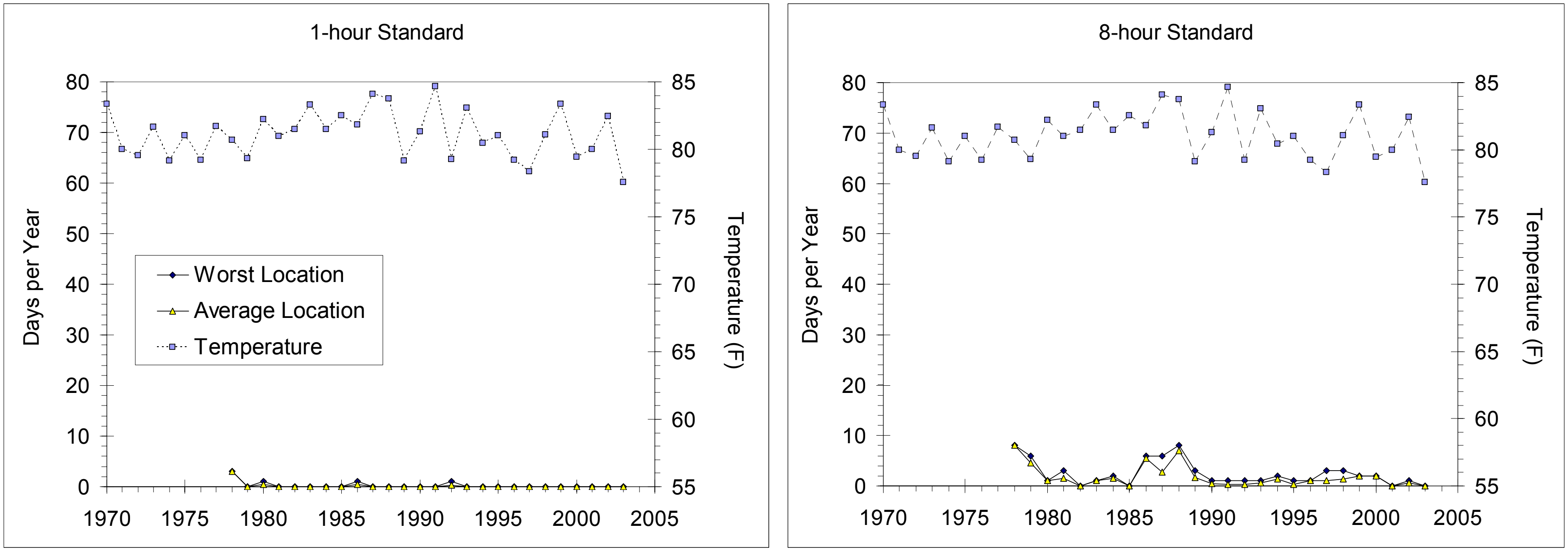


Buffalo

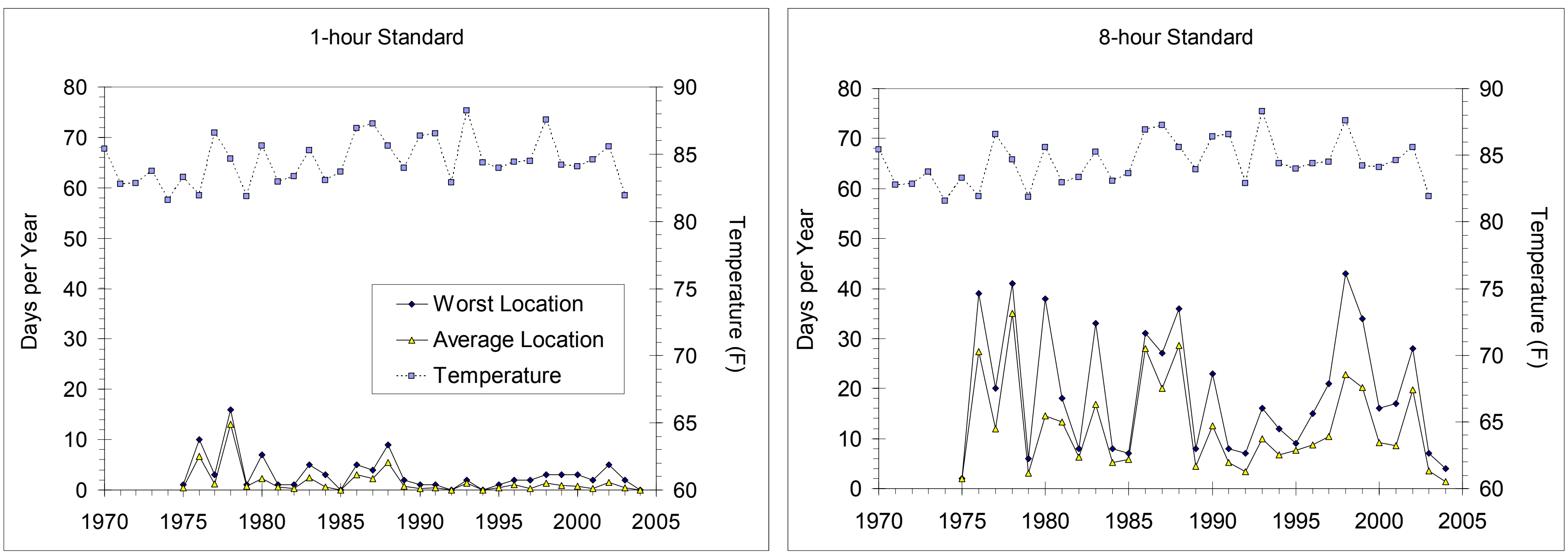




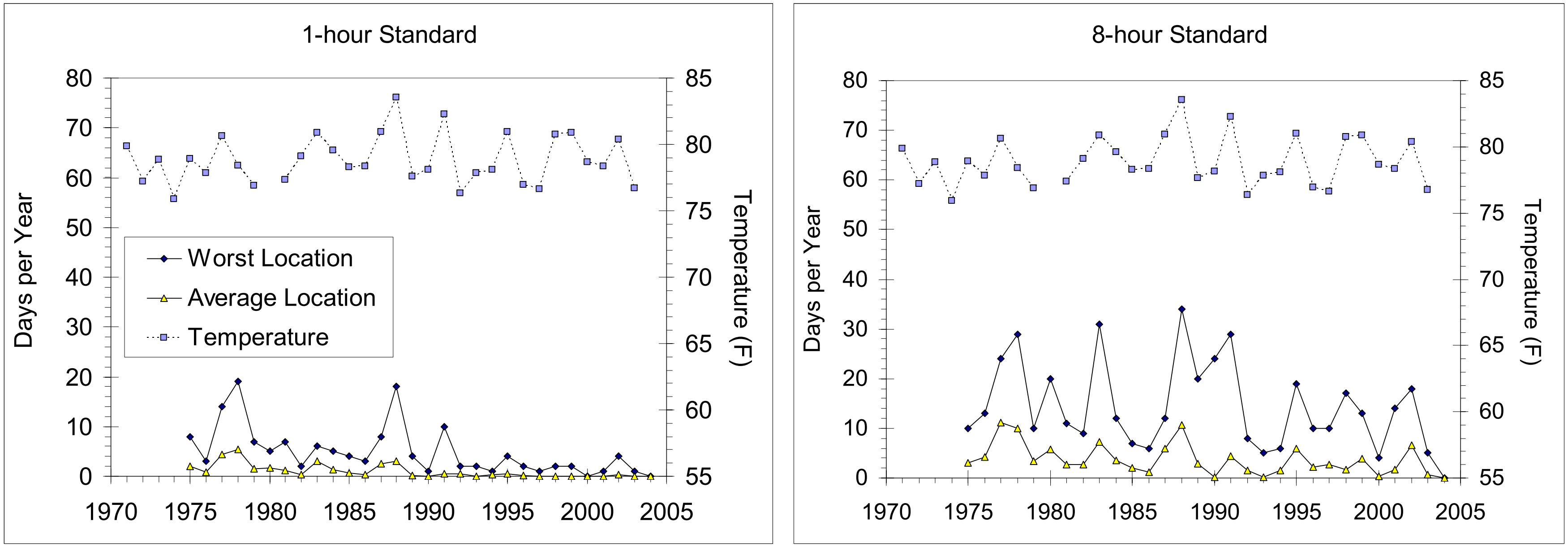
Charleston



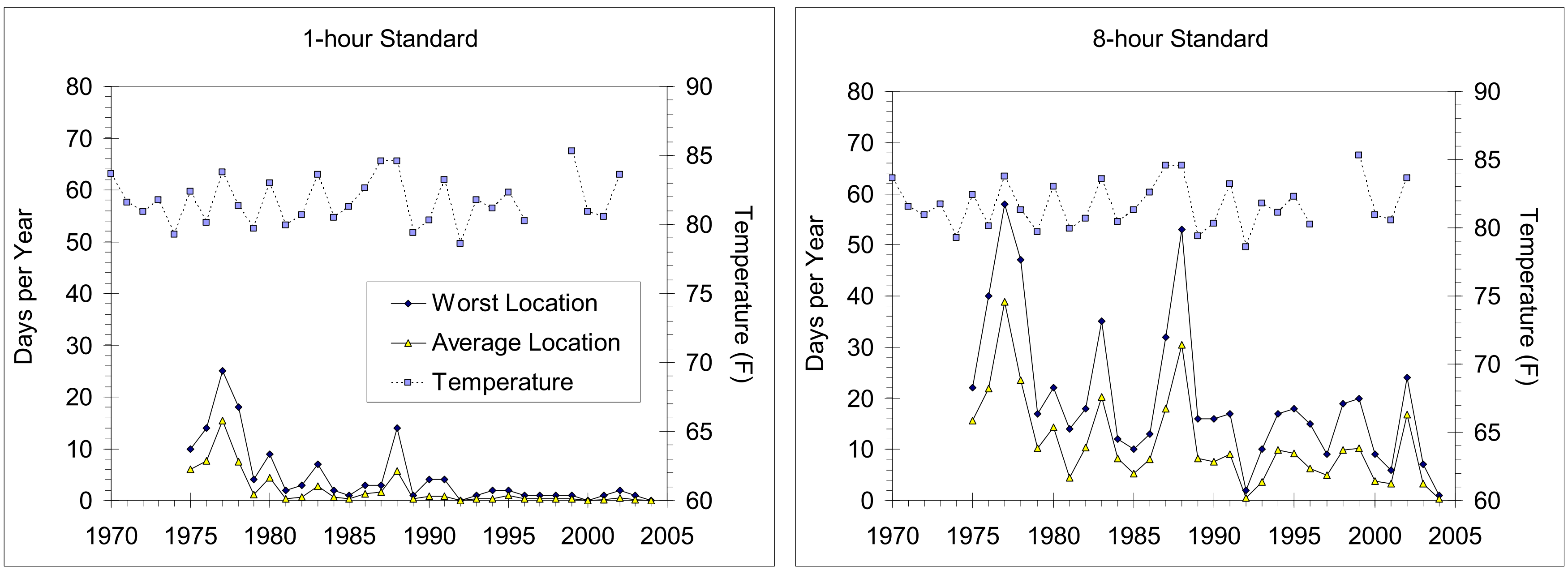
Charlotte



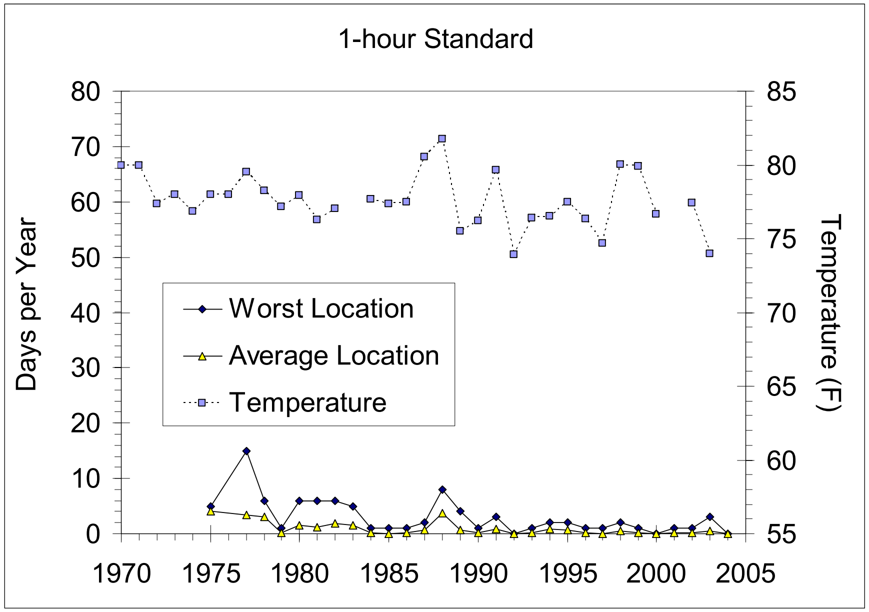
Chicago

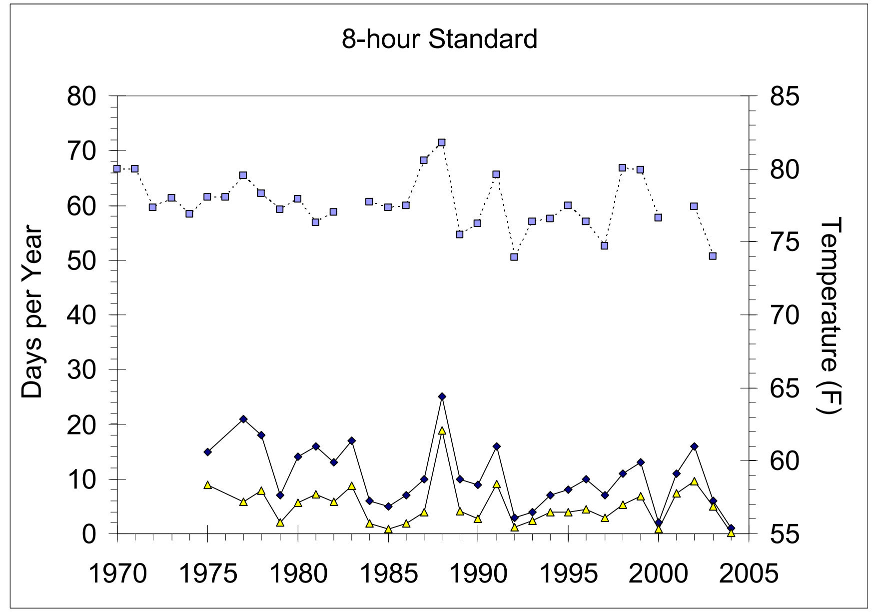


Cincinnati

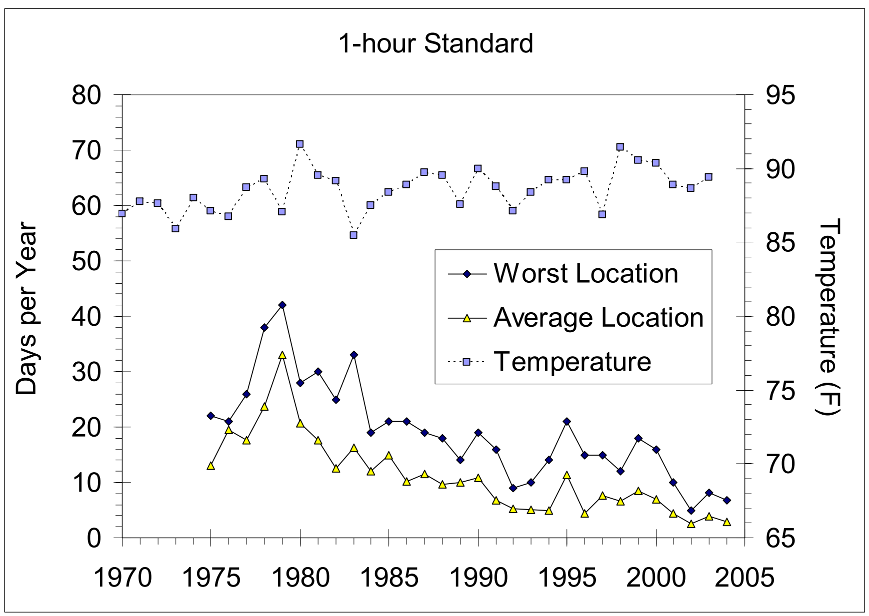


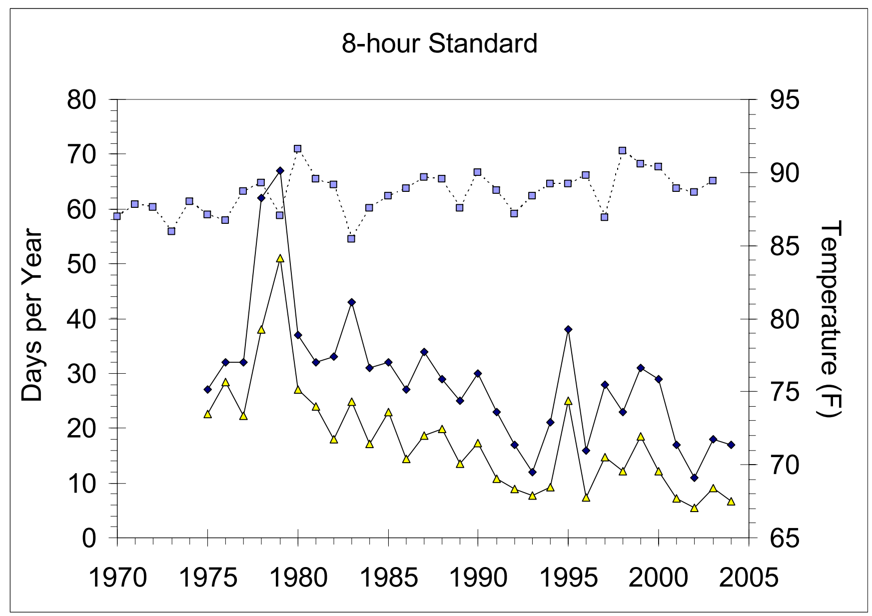
Detroit



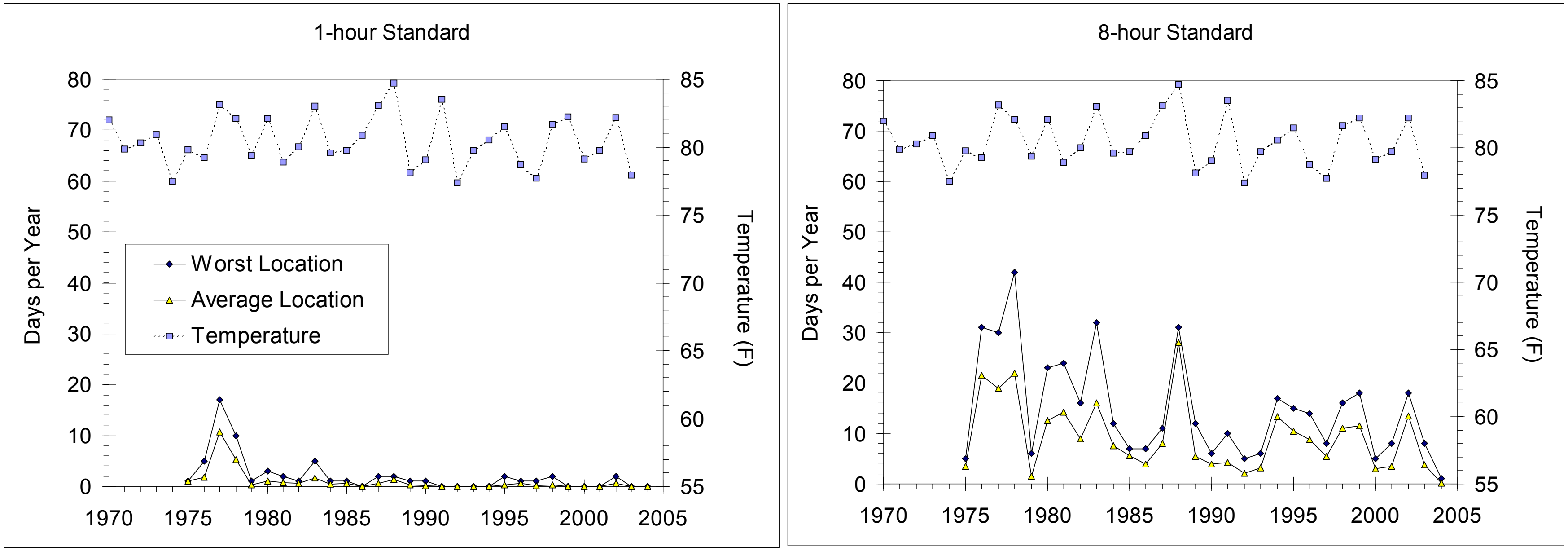


Houston

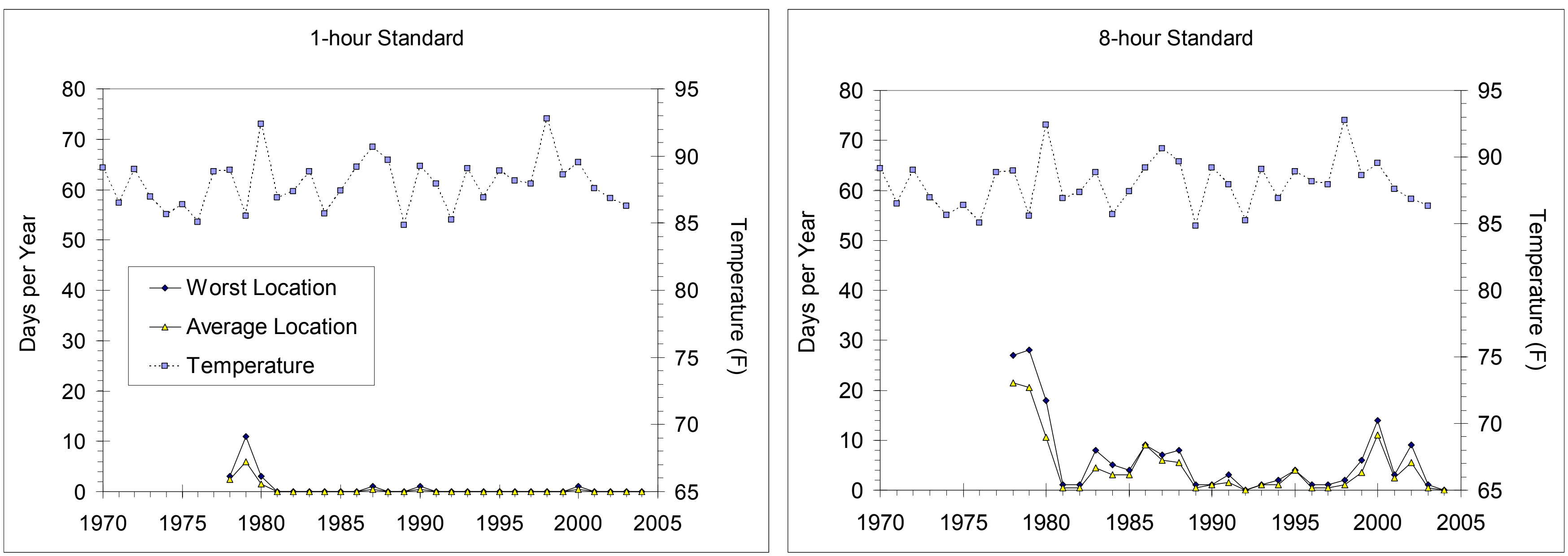




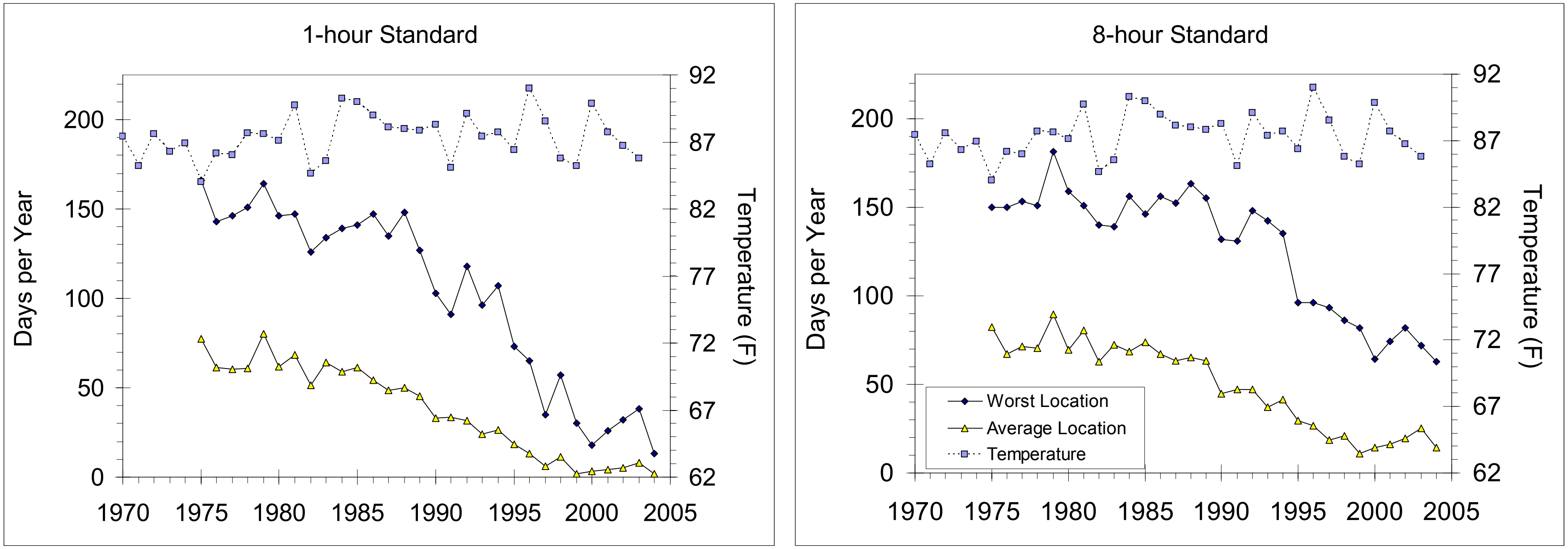
Indianapolis



Little Rock

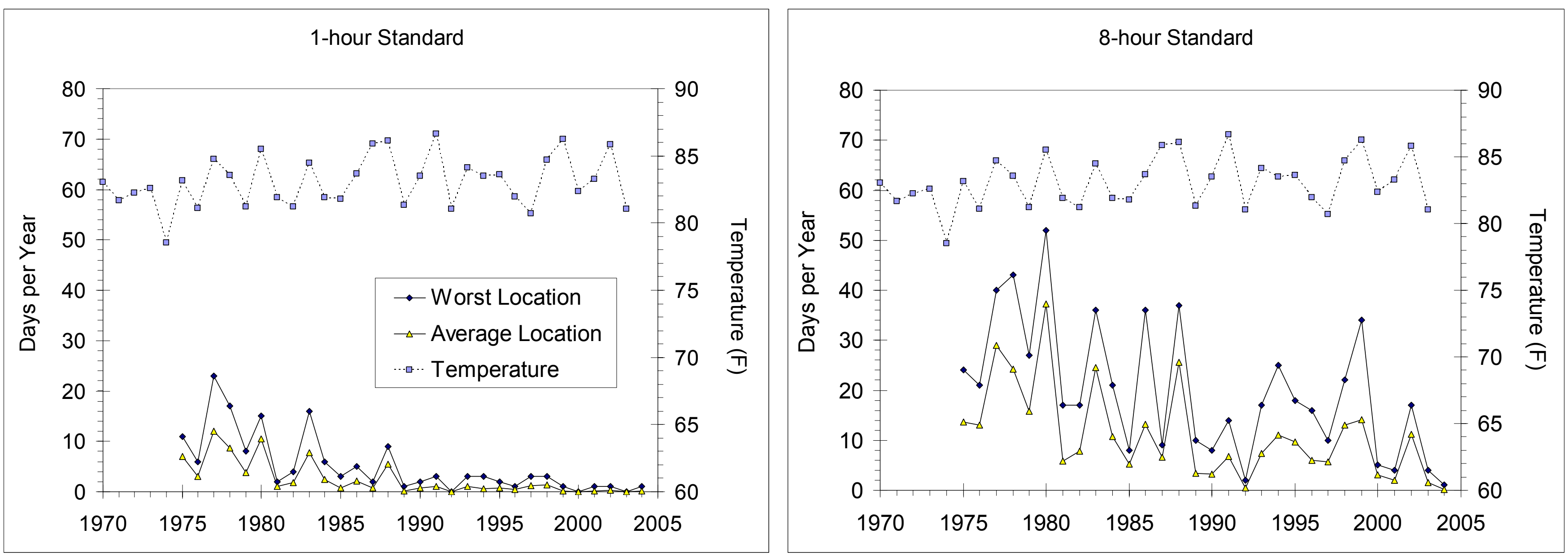


Los Angeles

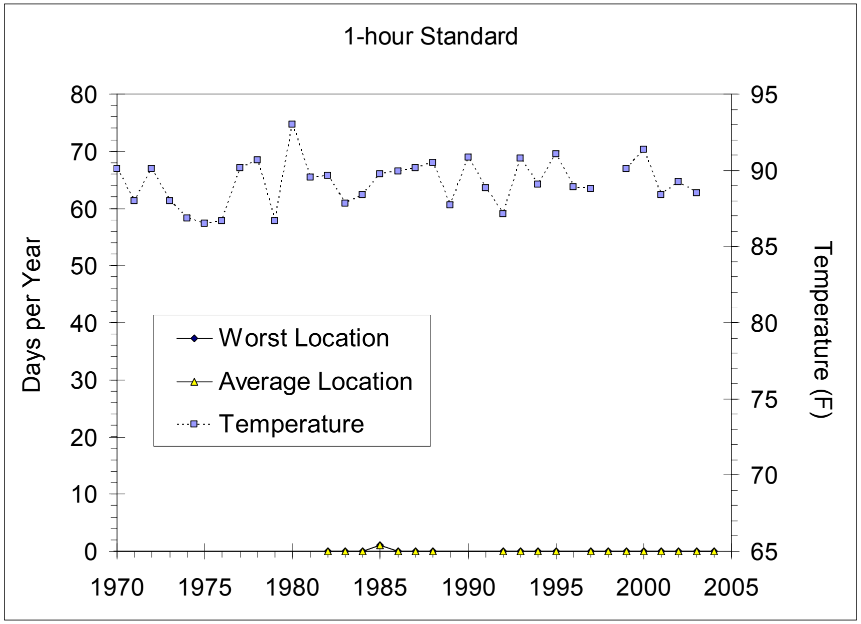


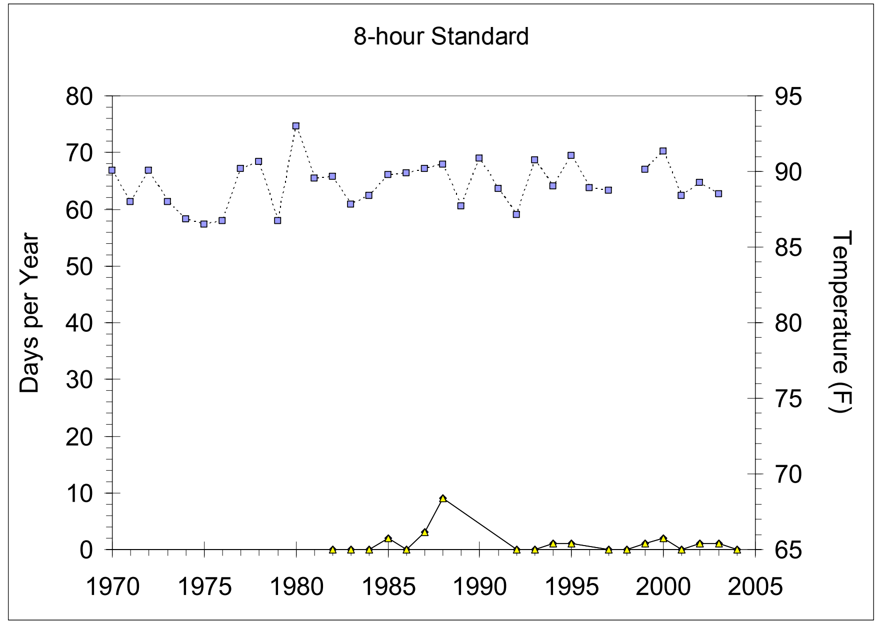
Note that the Los Angeles graphs have a larger vertical scale for ozone exceedance days per year than graphs for other metro areas

Louisville

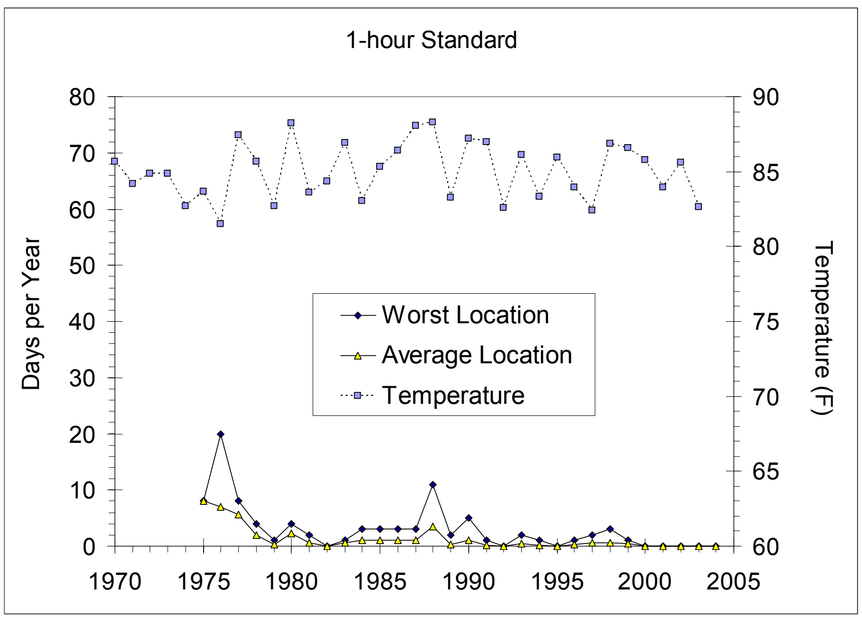


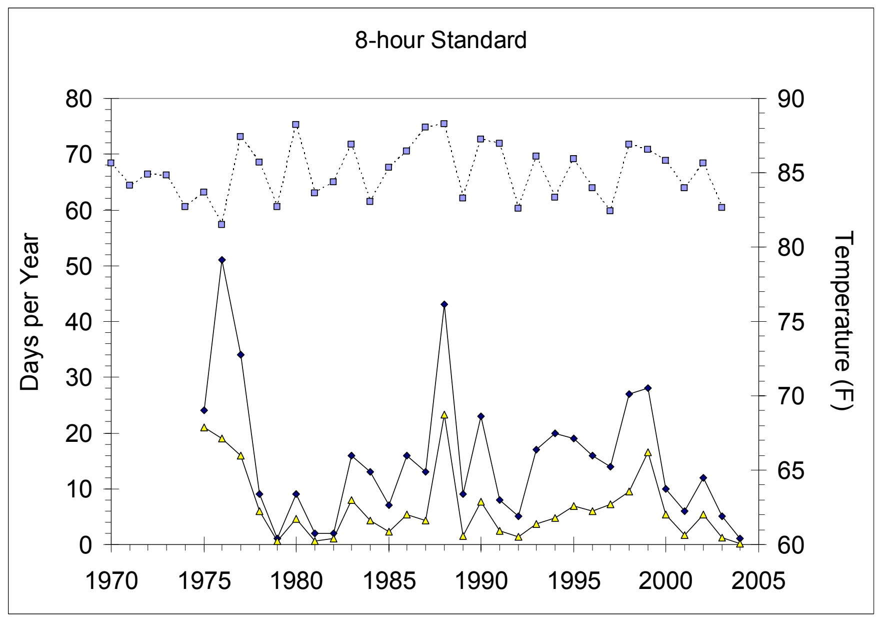
Monroe, LA



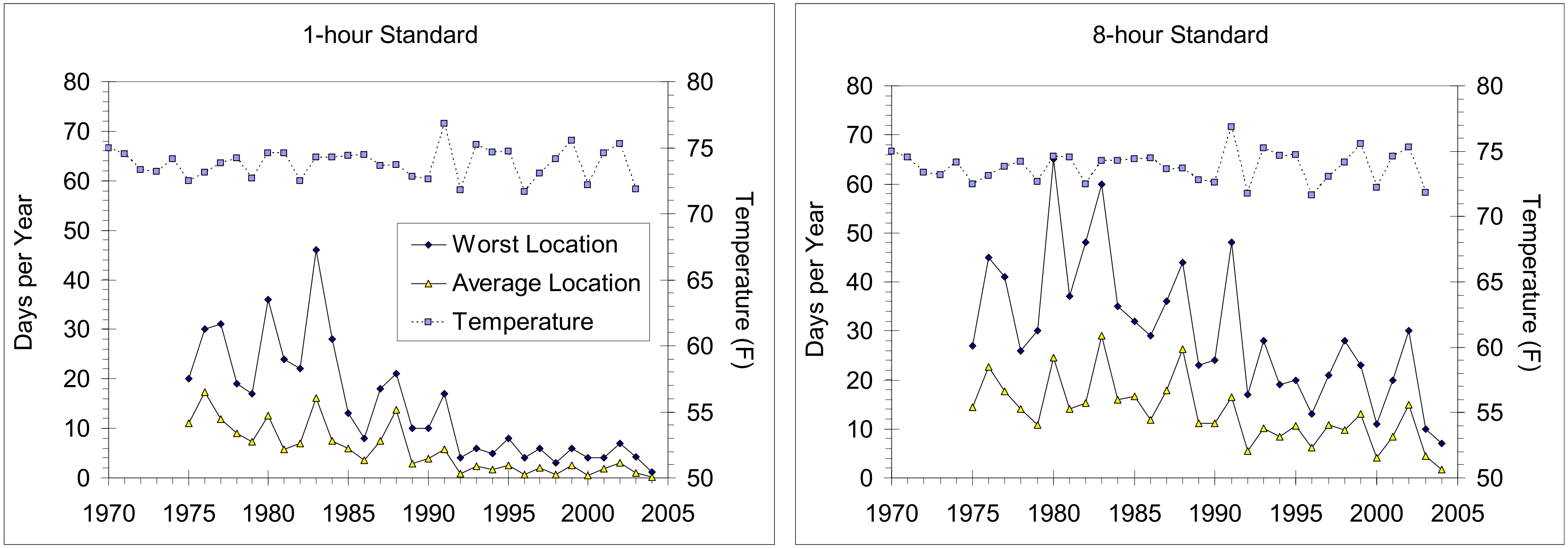


Nashville

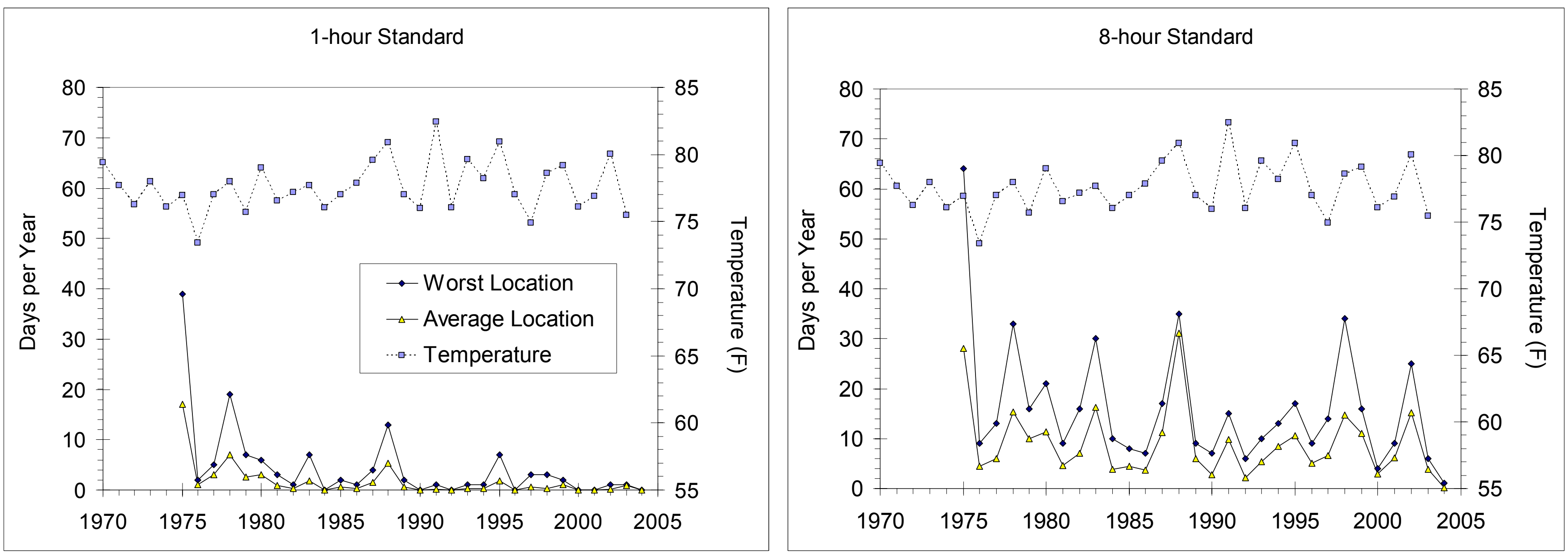




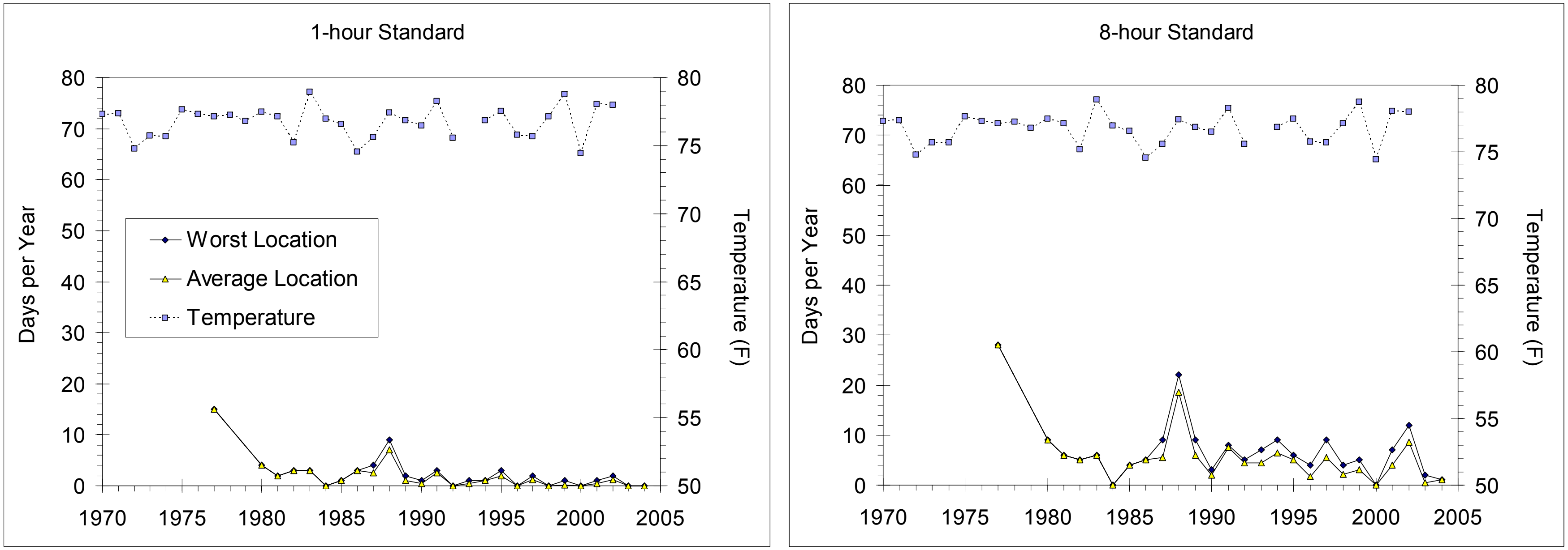
New York



Pittsburgh



Portsmouth, NH



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He is also past president of the American Association of State Climatologists. He is a member of the American Meteorological Society and has received certification as a Certified Consulting Meteorologist by the Society. He has published over 200 reports, symposium articles, and journal articles.

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About United for Jobs

United for Jobs is a project of the National Black Chamber of Commerce, the Small Business and Entrepreneurship Council and the National Association of Neighborhoods.

The project's goal is to educate citizens about how key environmental proposals may impact jobs, nationally and in each state.

For more information on United for Jobs visit www.united4jobs.org.

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Commonwealth Foundation for Public Policy Alternatives is a non-partisan, non-profit public policy research and educational institute located at the foot of the Capitol in Harrisburg.

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In the 1700s, North Carolina was called a "vale of humility between two mountains of conceit." It often charted its own course. North Carolina patriots were the first in America to call for independence. The state refused to ratify the U.S. Constitution without a Bill of Rights. And its state motto, Esse Quam Videri, translates as "To Be Rather Than To Seem." Honoring this tradition, a group of North Carolinians in 1990 created the John Locke Foundation as an independent, nonprofit think tank that would work "for truth, for freedom, and for the future of North Carolina."

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