CLIMAS Update

News from the Climate Assessment for the Southwest Project

Integrating science, policy, and community

THE UNIVERSITY OF ARIZONA®

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Announcements

• The 5th Symposium on Fire and Forest Meteorology will be held in Orlando, Florida on November 17–20, 2003. The 2nd International Wildland Fire Ecology and Fire Management Congress will be held concurrently. For more information see http://www.ametsoc.org/meet/FAINST/5fire2fireeco.html.

• Chicago will be the scene of the American Anthropological Association's 102nd Annual Meeting, November 19–23, 2003. This year's theme is "Peace." Visit http://www.aaanet.org/mtgs/mtgs.htm for details.

• The American Geophysical Union will hold its 2003 Fall Meeting December 8–12 in San Francisco. For more info, see http://www.agu.org/meetings/fm03/.

• The 84th American Meteorological Society Annual Meeting will be held January 11–15, 2004 in Seattle, Washington. For more info, see http://www.ametsoc.org/ .

CLIMAS Mission

CLIMAS was established to assess the impacts of climate variability and longer-term climate change on human and natural systems in the Southwest. Our mission is to improve the ability of the region to respond sufficiently and appropriately to climatic events and climate changes.

CLIMAS Studies Air Quality Trends, Variables in Southwestern Cities

As cities in the southwestern United States grow, air quality may decline. Ozone and particulate matter are of particular concern in this region, because both can have negative effects on human health, agriculture, ecosystems, and visibility. To limit these pollutants and their ill effects, governments have set standard maximum levels known as National Ambient Air Quality Standards (NAAQS). To gauge and improve the effectiveness of these policies, air quality trends are monitored over time. However, pollutant levels are strongly influenced by meteorological conditions, which can make it difficult to know whether air quality is improving or not.

CLIMAS researchers Andrew Comrie and Erika Wise have set out to develop tools to help air quality planners and managers better understand the link between climate and pollutants, in order to choose the most effective pollutant reduction strategies and avoid exceeding the NAAQS.

CLIMAS' air quality project will examine tropospheric ozone and particulate matter (PM) in major metropolitan areas of the Southwest, including Las Vegas, Phoenix, Tucson, Albuquerque, and El Paso. Ozone and PM were chosen for the study because they are pollutants of concern for air quality managers due to frequent NAAQS exceedances and their negative effects on human health, commercial crops, natural areas, and visibility. The CLIMAS climate and air quality initiative will attempt to separate underlying changes in air quality from year-to-year climate and weather variability, to identify which meteorological variables exert the most influence over air quality in the Southwest, and to determine air quality trends in the region.

This project was designed to provide air quality managers and decision makers with better information on the climatic influences on air quality by involving them in the research process. In December 2002, an Air Quality and Climate Variability taskforce was assembled, consisting primarily of members from local, state, and federal environmental agencies. Their feedback on the research project was used to shape and focus the research goals in a direction that will provide them with the most useful information possible. This stakeholder group will meet twice a year in order to provide continuous feedback as the project moves forward.

The choice of analysis techniques is crucial for accurately evaluating the data. The first phase of the study used the Kolmogorov-Zurbenko (KZ) filter to examine ozone in Tucson. The KZ filter separates air quality and atmospheric data into a short-term

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What We've Been Up To…

CLIMAS Outreach Assistant staff scientist Gregg Garfin, along with graduate research assistant Colin West and NASA Space Grant intern Melissa Chavez, participated in the February 2003 Southeastern Arizona Ag Day and Trade Show in Willcox, Arizona.

Barbara Morehouse attended "Human Dimensions of the Arctic System" on May 1–2 in Arlington, Virginia. The NSF-sponsored meeting was intended to help establish how social science might be integrated into its assessment of climate change in the Arctic.

CLIMAS investigators attended the Regional Integrated Sciences and Assessments (RISA) National Program Meeting in Scottsdale, Arizona, March 11–13. The meeting brought together the six RISA teams for presentations and panel discussions on refining RISA research, building regional research capacity, and strategic planning for the future of the program.

Drought Research & Outreach Gov. Janet Napolitano signed Executive Order 2003-12 creating Arizona's first Drought Task Force at a press briefing sponsored by CLIMAS and SAHRA on March 20 in Phoenix.

CLIMAS investigators Gregg Garfin, Barbara Morehouse, and Andrew Comrie, and graduate research assistant Joe Abraham, received state funding through the Water, Economic Development, and Sustainability Program for their project, "Tailored Drought Planning for Arizona." In cooperation with the recently formed Arizona Drought Task Force, the project will provide research on drought and its impacts in Arizona, as well as drought education and outreach products. Collaborators include Sharon Megdal of the University of Arizona Water Resources Research Center, Kathy Jacobs of the Arizona Department of Water Resources, and Don Wilhite of the National Drought Mitigation Center.

Congratulations to graduate research associate David Brown, who was one of four University of Arizona graduate students selected to receive a Technology and Research Initiative Fund (TRIF) Water Fellowship Award. The award will assist Brown in pursuing his doctoral dissertation research on sub-regional climate variability in the Southwest.

CLIMAS principal investigator Jonathan Overpeck and Gregg Garfin gave presentations on drought and climate change, and the END InSight project, respectively, at the first meeting of the Arizona Drought Task Force on May 8 in Phoenix.

Garfin served on the steering committee for the Drought Summit held May 12–13 at Northern Arizona University. He also facilitated the climate issues working group. A proceedings volume, containing the recommendations of the working groups, will help inform the Arizona Drought Task Force. The volume is expected to be available by August 2003.

CLIMAS Wishes Farewell…

The entire CLIMAS team extends its very best wishes and appreciation to our colleague Roger Bales, who has accepted a founding faculty position at the new University of California-Merced campus. Bales, who served as principal investigator on CLIMAS from its initial funding in February 1998 until the end of the 2001–2002 budget year, has provided invaluable leadership and intellectual insight throughout his tenure on the project. As principal investigator on a NASA-funded Remote Sensing and Applications Center, he directed research activities that ultimately benefited CLIMAS as well. Bales will continue as a CLIMAS co-investigator during the 2003–2004 budget year, specifically with regard to his research on the interactions between climate and water supply. We anticipate that, in subsequent years, his research activities will continue to contribute to the kinds of hydroclimatological research needed to better manage water resources in the face of climatic variability and change in the Southwest.

Climate Prediction & Variation CLIMAS intern Melissa Chavez presented results of her research on frost occurrence variability in southeastern Arizona at the 12th annual NASA Space Grant Statewide Symposium on April 26 at Arizona State University.

Climate & Fire Barbara Morehouse attended the Ecological Restoration Institute's Southwest Fire Initiative Conference at Northern Arizona University in Flagstaff on April 29. The conference focused on improving tools and methods for fire planning. She also participated in the Governor's 1st Annual Forest Health and Safety conference held March 10 at the Embry-Riddle Aeronautical University in Prescott, Arizona.

CLIMAS played a major role in organizing the Joint Fire Science Program/National Fire Plan Wildland Fire Workshop, held at the University of Arizona March 26–27. Some attendees also went to the Bullock fire site on Mount Lemmon on March 25. The workshop brought together land managers, technical specialists, and research scientists in a forum intended to allow participants to come to a common understanding of the key components of the fire season; identify the research available to assist decision makers in dealing with the aftermath; and agree upon the most urgent research priorities for the near term. The Tucson workshop was the second of three workshops being held in strategic geographic locations to take advantage of the insights gained from the big 2002 fires in Arizona, Colorado, and Oregon.

Climate & Water Management Bonnie Colby, co-PI of the CLIMAS economics

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Submissions and Publication Information

CLIMAS Update is published quarterly and welcomes the submission of items of interest. The editorial staff reserves the right to select and edit copy submitted for publication. All material in the newsletter may be reproduced, provided CLIMAS is acknowledged as the source. The newsletter is provided through the support of the National Oceanic and Atmospheric Administration (NOAA).

Deadline for next issue: September 1, 2003
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Streamflow Forecast Assessment

Streamflow forecasts are important to many stakeholders across the West, as they provide a basis for water supply planning, wildlife management, recreation/tourism interests, and other uses. Assessing the accuracy of such forecasts is an important step in allowing stakeholders to effectively use them, and is also necessary if forecasters are to improve them. CLIMAS post-doctoral researcher Jean Morrill, under the guidance of UA Department of Hydrology and Water Resources principal investigator Roger Bales, has recently completed a study that sheds light on this issue.

The Colorado Basin River Forecast Center issues seasonal water supply outlook forecasts that are used by stakeholders interested in knowing what volume of seasonal flow is most likely to occur. The period for which forecasts are made (i.e., the forecast period) has varied over time, but now is generally April–July in the Upper Colorado River Basin and January–May in the Lower Colorado River Basin.

Morrill's study compared forecasts with "observed" values at 55 forecast sites in the Colorado River Basin (Figure 1). The forecast flows represent the flows that would occur at each site in the absence of diversions (such as dams, irrigation, or municipal use). The actual observed flows are combined with data about withdrawals and diversions to reconstruct what the flows at each of the sites would have been in the absence of these activities.

At each site, the observed flows were used to determine three flow levels for each forecast period: low flows (the lowest 30% of observations), moderate flows (the middle 40%) and high flows (the highest 30% of observations).

Several different statistical tests were used to examine whether the forecast flow and the observed flow fell in the same flow category for each month (January–May) that a forecast was issued. These included basic statistical tests, such as root-mean-square error and correlation; categorical tests, such as hit rate, threat score, probability of detection and false alarm rate; probabilistic tests, such as Brier scores and rank probability scores; and distributive statistics, such as resolution, reliability, and discrimination.

The study revealed that predictions of flows on the majority of streams have been very conservative. As shown in Figure 2, below-average flows are often over-predicted (forecast values are too high) and above-average flows are under-predicted (forecast values are too low). This problem is most pronounced for early forecasts (i.e. January) at many locations, but improves with later forecasts (i.e. May).

Two measures were employed to judge the accuracy of the forecasts. The probability of detection (POD) is the probability that the forecasted flow will match the observed flow. The highest score is 1, the lowest score 0.

The false alarm rate (FAR) is the probability that the observed flow will not match the forecasted flow. Here, the *highest* score is 0 and the *lowest* score is 1. In other words, this criterion tracks how often the category given the greatest probability has turned out to be "wrong," relative to how many times that category has been forecasted.

Figure 1. Location of the 55 forecast points used in this study.

In a perfect set of forecasts, POD=1 and FAR=0 at the same time. Figure 3 shows the distribution of these measures in March for 55 sites.

For the low and high flows there is a low false alarm rate, which means than when low and high flows are forecast, those forecasts are generally accurate, and such flows do occur. However, for low and high flows there is also a low probability of detection at most sites—in other words, low and high flows actually occur far more often than they are forecasted.

Moderate flows, on the other hand, have a very high probability of detection, but also a very high false alarm rate, indicating that moderate flows are forecasted more frequently than they actually occur.

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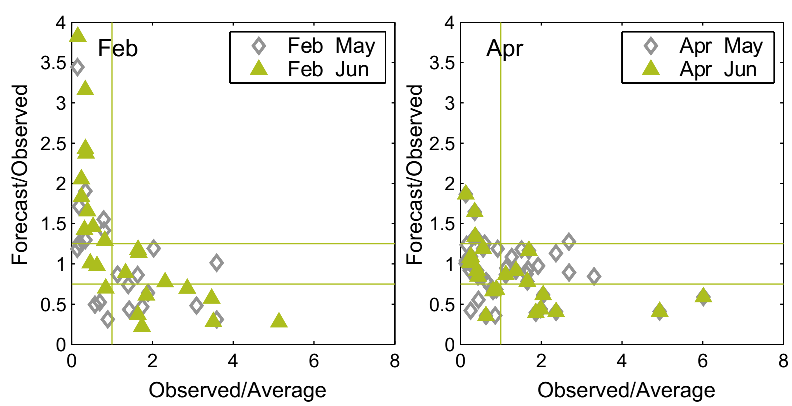

Figure 2. Plot of forecast/observed values (>1 over-predicted, <1 under-predicted) against observed/average observed flow (> 1 above-average flow, < 1 below-average flow) for the Salt River near Roosevelt (Lower Colorado River Basin). Upper-left section of plot represent below-average flows that are over-predicted, lower right section above-average flows that are under-predicted.

Streamflow (cont. from page 3)

There is good discrimination between high and low flows, particularly with forecasts issued later in the year. This means that when high flows are forecasted, low flows rarely occur, and vice versa.

The accuracy of forecasts tends to improve with each month, so that forecasts issued in May tend to be much more reliable than those issued in January.

A more detailed version of these results will soon be available online, giving decision makers who use streamflow forecasts an accessible source of information about streamflow forecast accuracy. This will allow them to better use streamflow forecasts for planning and monitoring water resources.

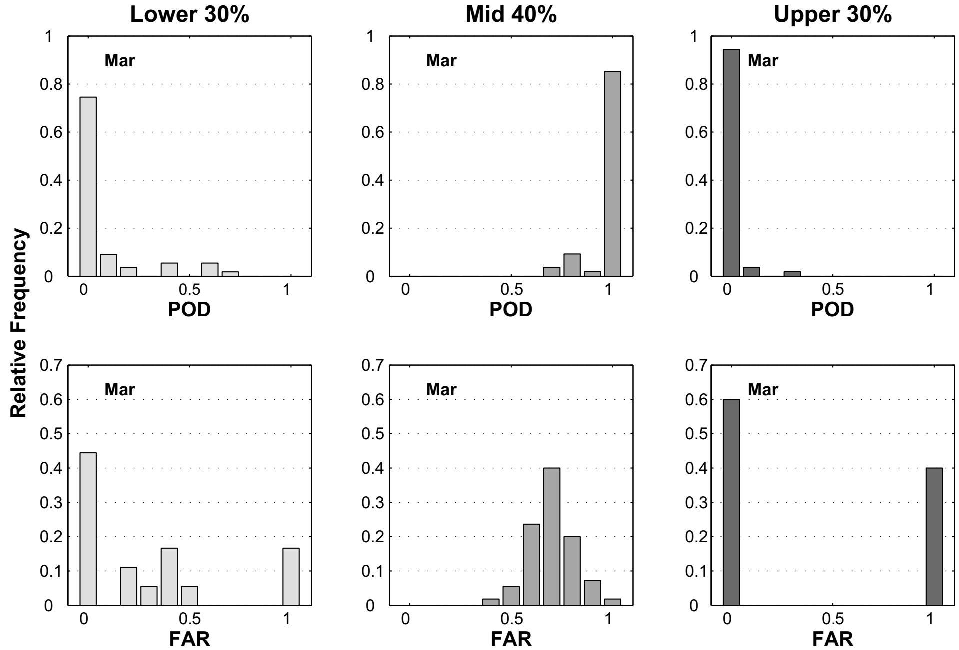

Figure 3. The relative frequency of probability of detection (POD) and the false alarm rate (FAR) at 55 sites in March. Perfect scores would be POD=1, FAR= 0 for all sites.

What We've Been Up To (continued from page 2)

team, gave a workshop for stakeholders in the Upper Rio Grande north of Albuquerque. The workshop explored tools for cost-effectively coping with drought in over-allocated river basins and for designing inter-jurisdictional water management agreements that will remain stable and workable during severe drought. Workshop attendees included federal and state water managers and representatives from pueblos, counties, municipalities, and private firms.

Gregg Garfin, CLIMAS investigator Roger Bales, and graduate research assistant Noah Molotch attended the 71st Annual Meeting of the Western Snow Conference, in Scottsdale, Arizona, April 23–24. Bales and Molotch presented papers on CLIMAS snow cover modeling research.

Climate & Agriculture Dan Osgood, along with his colleagues Daniel Bronson and Mary Kay O'Rourke, gave a presentation about climate, pesticides, and children's health entitled, "Trade-offs in Agriculture and Children's Health: A Space, Time, Climate, Occupational, and Household Based Damage Function for Pesticide Exposure." The presentation was at the Association of Environmental and Resource Economists session of the annual Allied Social Science Association Meetings, which took place in Washington, D.C. January 2–5.

Osgood also met with extension economists across the western United States to discuss the use of CLIMAS-type climate information in farm and ranch extension. They met during the 2003 Western Farm Management Extension Committee Meeting, January 12–15 in Las Vegas. The group subsequently received funding from USDA's Western Center for Risk Management Education to integrate climate education into the Right Risk Ranch Management education internet game. Such management and training programs are currently being provided to ranchers across the West.

CLIMAS members Gregg Garfin and Dan Osgood, Arizona Cooperative Extension associate director for programs Deborah Young, and University of Arizona biometeorology specialist Paul Brown developed a workshop to assess and help meet the climate information needs of Arizona Cooperative Extension agents, specialists, and rural Arizona communities. The workshop was held on May 29 at the University of Arizona and featured presentations by a variety of hydroclimatological information providers in Arizona.

Garfin attended "Land Management in a Changing Climate," a workshop hosted by Arizona State University East on April 25. The workshop was intended to examine practices of sustainable management of natural and human built habitats in arid Southwest landscapes under non-stationary climatic conditions.

Border Issues CLIMAS PI Diana Liverman served on the executive committee to organize the Fourth Meeting on Border Environment (Encuentro Fronterizo), held in Tijuana, Baja California, Mexico on May 15–17. The meeting brought together community organizations, activists, researchers, and other individuals who work on U.S.-Mexico border environmental issues. The Encuentro is designed to bridge political, cultural, and geographic barriers and enable discussion and reflection on environmental issues of common concern along the 2000-mile span of the border region. CLIMAS postdoc researcher Rebecca Carter also attended the meeting.

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We have created a new listserv to provide you with the latest news from the CLIMAS project. Subscribers will receive periodic announcements about CLIMAS-sponsored events and new publications, as well as the latest drought updates. To join visit:

http://www.ispe.arizona.edu/climas/subscribe.html.

Researcher Looks to ENSO Indices to Improve Winter Forecasts

There are many ways of determining variability in the El Niño-Southern Oscillation (ENSO) system, which is known to have effects on Southwest winter precipitation, and developing that information for use in climate forecasting. Sea surface temperature (SST) anomalies in the eastern and central equatorial Pacific Ocean often provide a first indication of ENSO behavior. The Niño 1+2, Niño 3, Niño 4, and Niño 3.4 SST indices have all been developed to monitor ENSO, but each has a unique geographic extent (Figure 1).

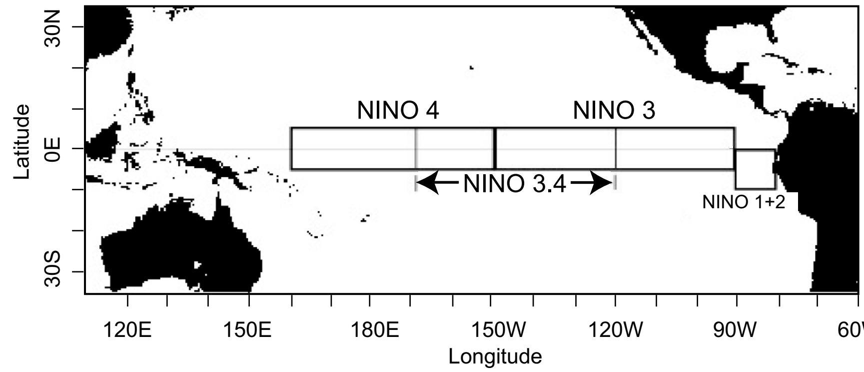

Figure 1. Location and spatial extent of the Niño 1+2, Niño 3, Niño 4, and Niño 3.4 SST indices.

In contrast, the Southern Oscillation Index (SOI) captures the atmospheric evidence of ENSO variability through a measure of sea level pressure differences in Tahiti and Darwin, Australia. Recently, Klaus Wolter and Michael Timlin of the NOAA Climate Diagnostics Center developed the Multivariate ENSO Index (MEI), which combines a suite of climate variables to provide a more robust measure of ENSO behavior than either SST or atmospheric pressure anomalies alone.

Because the impacts of El Niño and La Niña events often lag behind measured ENSO anomalies by several months, seasonal averages of these six indices during spring, summer, and fall correlate with precipitation the following winter in the Southwest, and are thus useful for climate forecasting. CLIMAS researcher David Brown, under the guidance of Andrew Comrie, conducted a correlation analysis to determine which ENSO measures are best associated with winter precipitation variability in the Southwest. The results reveal subtle nuances between ENSO indices, which may be important for forecast development, including

- Extended (2-3 seasons) lagged relationships are best captured by the SOI and Niño 4 indices.
- The Niño 1+2 and Niño 3 indices are consistently the least well correlated with winter precipitation in the southwestern United States.
- For no season is the MEI index most well correlated with Southwest winter precipitation.

These findings may be useful to stakeholder groups who rely on multi-season forecasts of winter precipitation in Arizona and New Mexico. It is important to note, however, that these correlation relationships may be modulated on an interannual basis by other large-scale climate forcings such as the Pacific Decadal Oscillation.

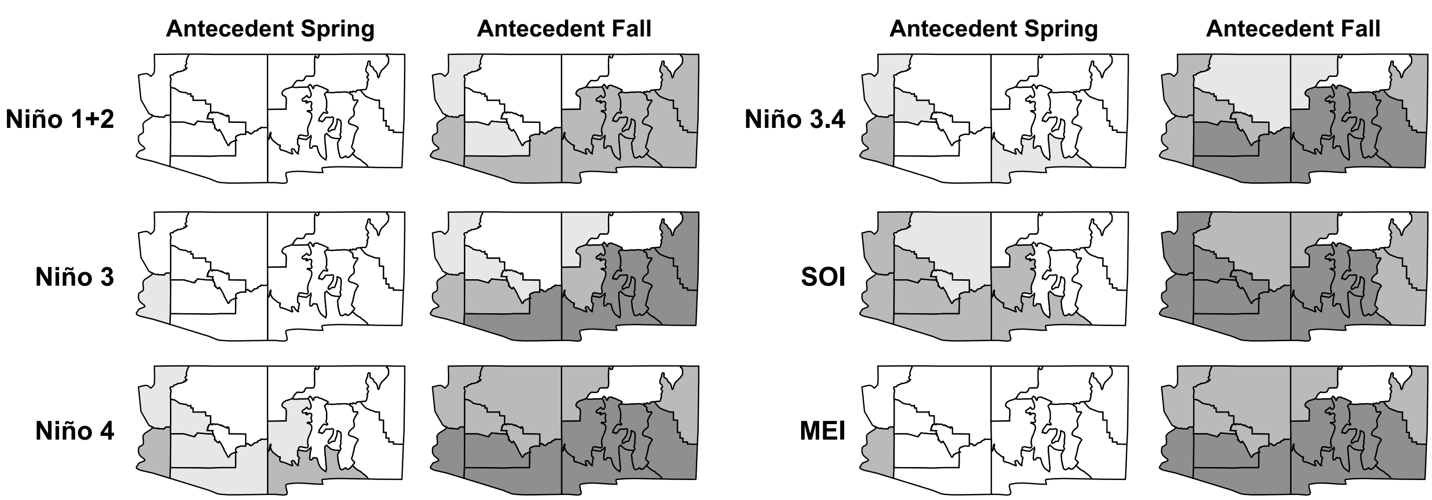

Figure 2. Statistically significant (light shading = 90% confidence; medium shading = 95% confidence; dark shading = 99% confidence) correlations between spring (March – May) and fall (September – November) ENSO index values and subsequent mean winter (December – February) precipitation in Arizona and New Mexico for the period 1901–1995.

Air Quality (continued from page 1)

component (variation due to weather), a seasonal component (solar variation), and a long-term trend component (change attributable to long-term climate change or policy changes) (Figure 1). Through regressions on the components of the air pollutant and one or more meteorological variables, climatic influences can be separated from air quality trends (Figure 2).

Although days on which air quality standards will be exceeded are largely unpredictable, researchers are able to identify atmospheric and other conditions that are likely to cause standards to be exceeded at certain times and locations. Separating climatic influences from other influences on air quality (e.g. auto emissions, dust, etc.) will allow managers to evaluate the relative contributions of these factors to diminished air quality. This in turn will allow planners and regulators to develop strategies that will lead to reductions in emissions and improve the efficiency and cost-effectiveness of their efforts.

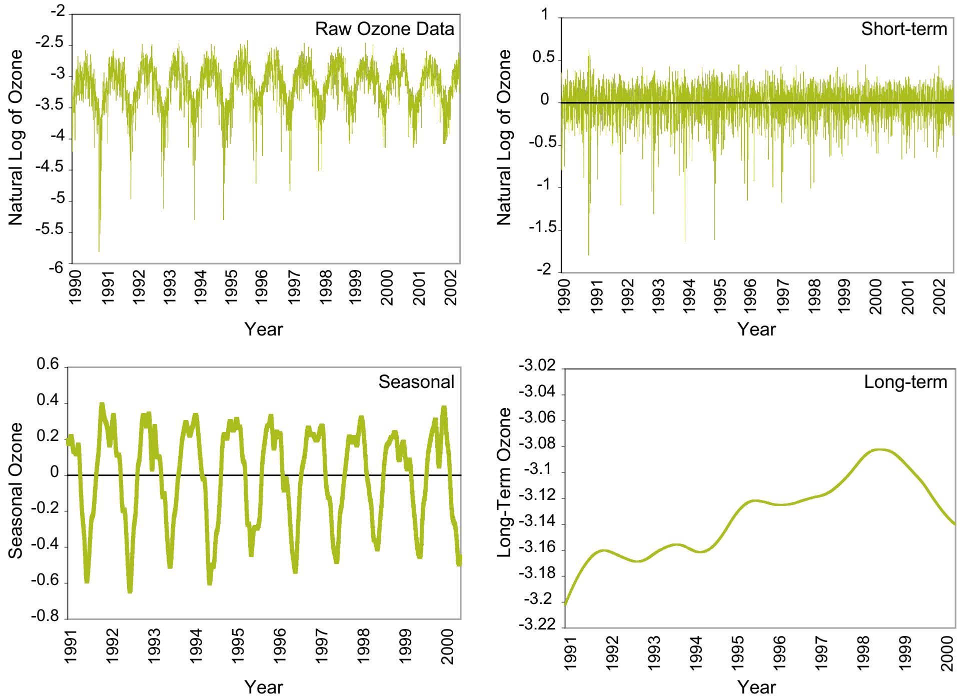

Figure 1. The KZ filter breaks down the log-transformed raw ozone data (upper left) into short-term (upper right), seasonal (lower left) and long-term (lower right) components.

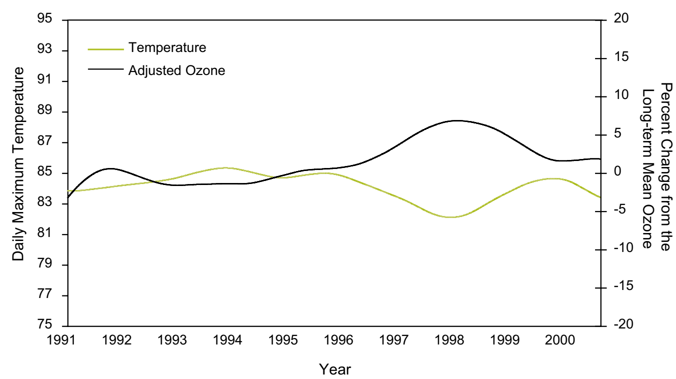

Figure 2. The meteorologically adjusted tropospheric ozone trend and long-term daily maximum temperature trend in Tucson is shown. The adjusted ozone shows the underlying trend without the effects of temperature. For example, in 1997-1999 temperatures were low and ozone levels were normal, but the adjusted ozone trend shows a peak due to changes in emissions.

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