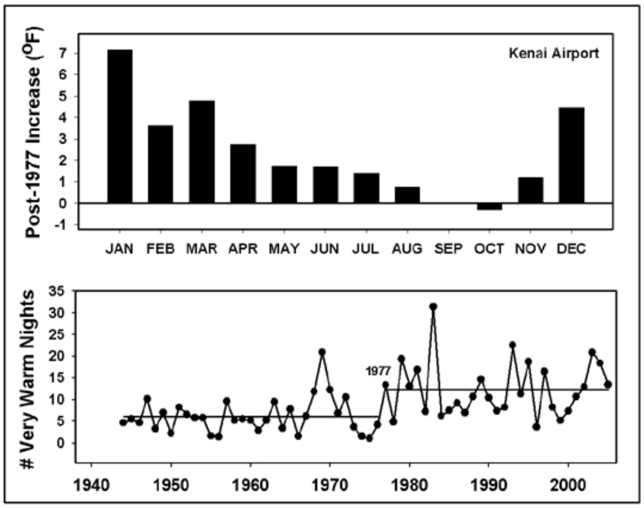
Warmer winters and warmer nights a mixed blessing

by Ed Berg



Upper graph shows changes in average monthly temperatures since 1977. Average January and December temperatures have warmed much more dramatically than have summer temperatures. Lower graph shows the number of nights with temperatures in the top 10^{th} percentile. Straight lines shows averages. Most of the increase in very warm nights has occurred since 1977. (Kenai airport data; chart by Ed Berg)

Climatologists tell us that the Earth is warming up. We see lots of evidence of this warming in Alaska with melting permafrost, retreating glaciers, and a shrinking polar ice pack.

I have recently acquired a powerful software package that analyzes daily temperature and precipitation data; it focuses on extreme weather events using maximum and minimum daily temperatures. In the past I have used monthly averages for analyzing Kenai Peninsula climate data. Monthly averages tend to hide extreme temperature events—the scorchers and the two-dog nights. I have now obtained the daily data for the Kenai airport since 1944 and the Homer airport since 1932. With this new data and software, I am turning the climate microscope from low-power to high-power.

Climate can potentially warm in many ways, and these different ways have practical consequences. If only summers warmed, but winters stayed cold, glaciers would continue to melt but our heating bills would remain the same. Conversely, if only winters warmed, glaciers would not melt (or might even increase due to increased snowfall), and our heating bills would shrink.

So, how is the Kenai warming? Basically, all months are warming but winters are warming about three times as much as summers. Unfortunately, due to higher fuel prices, our heating bills are still going up, even though winter fuel consumption should be going down. The temperatures in many parts of the world warmed quite dramatically starting in 1977. In Alaska we usually attribute this climate warming to a sharp rise in North Pacific sea surface temperatures (which seriously reduced the shrimp fishery and boosted Gulf of Alaska salmon). But the warming was actually a worldwide warming that shows up in climate records over most of the Earth.

The upper graph shows the change in average monthly temperatures before and after 1977. December and January increased by 5 and 7°F, respectively whereas the summer average only picked about 2°F, as measured at the Kenai airport.

I made this pre- and post-1977 calculation using monthly averages, i.e., the low-power microscope. Let's now turn to the high-power, and look at the daily maximum and minimums. The lower graph shows that nighttimes (minimum temperatures) are warming; the average number of very warm nights (in the top 10^{th} percentile) has increased six to 12 per year after 1977. This is a worldwide trend, and it would be surprising if the Kenai was an exception. Here's how it works.

If the sun were shining brighter, it would heat up the daytime, just like putting more wood on a fire or turning up the furnace. But daytime warming probably wouldn't carry over to the nighttime. At night the Earth is losing heat and there is no sunshine to replace it.

Keeping warm at night requires good insulation. The atmosphere is the Earth's insulating blanket. Warmer nighttimes mean the Earth's atmosphere is becoming a better blanket. This is where the "greenhouse" gases come into play, especially water and carbon dioxide. Water in the form of clouds is the most potent greenhouse gas. Everyone knows that a cloudy winter night will be much warmer than a clear night, because of increased water vapor on the atmosphere. Nevertheless, satellite-based cloud studies show that for the whole Earth, clouds actually cool the atmosphere slightly because their blocking of solar radiation during daytime more than offsets their insulative effect during nighttime.

Furthermore, a recent study analyzed 2223 weather stations around the world, and found that nighttimes are warmer in every season: winter, spring, summer and fall. If increased cloudiness were the main factor, we would expect to see seasonal differences in nighttime warming, because many areas of the world have strong seasonal differences in cloud cover.

In short, the warmer nights appear to be due to increased carbon dioxide and, to a lesser extent, increased methane, nitrous oxides, and other minor greenhouse gases. Fossil fuel consumption is, of course, the primary source of elevated levels of carbon dioxide, followed by deforestation and burning in the tropics.

Personally, if the Earth is getting warmer, I would prefer to have warmer days for the sake of ecosystem stability, although I certainly wouldn't mind the lower heating bill associated with warmer nights. For most organisms, warmer days won't have a great impact; warmer nights on the other hand will be much more biologically significant. Nighttime is the coldest part of the 24-hour cycle: it is the thermal bottleneck. Relaxing this bottleneck should make winter easier on warm-blooded animals like moose and resident birds, but it can also make it possible for lots of exotic organisms—both animal and plant—to establish here that are less cold hardy than our present species.

Many cold-blooded organisms have fairly sharp temperature thresholds of lower (and upper) temperatures where they die. Spruce bark beetle larvae, for example, die at −40°F. In the Yukon winter nights at −40 can knock the beetle population down substantially the following spring, according to my Canadian colleagues. Minimum temperatures rarely get to -40 on the Kenai, so warmer winters are probably not going to influence bark beetle winter survival. With bark beetles it's the warmer summers (both days and nights) that really count, especially when a summer is warm enough for them to complete their normal 2-year life cycle in 1 year.

Domestic plants are a good example of organisms with clear lower temperature thresholds of winter mortality. In Homer, for example, apple trees have been growing so well in recent years that we now have a Lower Peninsula Fruit Growers Association. I suspect that such a development would not be possible without eliminating the killing extreme temperatures of the coldest winter nights.

It seems fairly obvious that making the coldest winter nights substantially warmer would make life easier for just about every kind of organism. What is not so obvious is the effect of warmer nights during the rest of the year and in warmer climates. In the Philippines, for example, a recent study attributed reduced rice productivity to warmer nights; rice yield declined by 10% for each 1°C increase in growing-season minimum (nighttime) temperature in the dry season, whereas the effect of maximum (daytime) temperature on crop yield was insignificant. Similar reductions have been observed in the U.S. with corn and soybeans.

Why would warmer nights reduce crop yields? During the day plants are using photosynthesis to make food for themselves. Like animals, plants are at all times burning up this food—day and night. At night however plants are only burning up food; on a warmer night they burn up more food than on a cool night. This consumption process—called "dark respiration"—competes with the process of growth; if a plant is kept completely in the dark, dark respiration wins and the plant burns up all its food and dies.

The reduction of crop yields could be another unpleasant consequence of global warming. Theoretical models forecast a 16% reduction in yield for corn, sorghum and soybeans in the central U.S. from a 3°C (5°F) rise in mean daily temperature. Much of this reduction would be due to increased dark respiration during warmer nights, but increased daytime drought stress could also be important.

How would warmer nights affect birds, insects, and other animals during the non-winter part of the year—what we call "summer" in Alaska? This is indeed and interesting question to ponder; probably most biologists have never asked this question because it hasn't been on their radar screen. It certainly never occurred to me before I began looking at this temperature data. For now I'll offer a few conjectures and revisit this topic in a future article when I have more information in hand.

Warmer nighttime temperatures will probably allow most animals to be more active at night; plant-eating animals will have more time to forage and they should grow better, but predators too can be more active, so there is more of a chance that the prey will get eaten. There will no doubt be winners and losers as this balance shifts, and it's hard to say how things will shake out. Personally I will bet on the predators.

Stream temperatures normally drop by a few degrees during the night; this nighttime cooling can keep fish healthy. Sue Mauger, a stream ecologist with Cook Inlet Keeper, recently reported that in 2005 the waters of Deep Creek, Stariski Creek, and the Ninilchik and Anchor Rivers each had more than 80 days when daytime temperatures exceeded the State-recommended limit of 55°F for salmon spawning. Too many warm water days can cause fungal diseases in fish and reduce the availability of nutrients and oxygen.

Fish breathe by using their gills to extract dissolved oxygen from water. Warm water holds less dissolved oxygen than cold water, and warm water—in both lakes and streams—encourages algae and phytoplankton growth, which further soaks up dissolved oxygen. These warm water problems are not specific to nighttime temperatures, but night is the time when streams recover from daytime highs, and warmer nighttime air temperatures may impede this recovery.

Warmer winters and warmer nights have their virtues, especially for those of us with old cars and old bones, but they may bring some changes we could just as well do without.

Ed Berg has been the ecologist at the Kenai National Wildlife Refuge since 1993. Previous Refuge Notebook columns can be viewed on the Web at http://www.fws.gov/refuge/kenai/.