possible positions!), as well as two forward-searching algorithms that kick in from the first move, analyzing possible outcomes of moves in terms of achieving a win, loss, or draw.

The database still does not contain all possible positions that can arise in the game. Compiling such a database, the authors say, though theoretically possible, would make playing the game "impractical with today's technology." It would take too long for the computer to crunch the data. Nonetheless, Schaeffer and colleagues believe that, armed with their current program, they could do no worse than tie a mistake-free player. (Even the great Tinsley lost three times from 1950 to 1991.)

Is there any significance to all of this, beyond mere game-playing? Schaeffer and his coauthors think so. "The project has been a marriage of research in AI and parallel computing, with contributions made in both of these areas"; they performed computations on up to 50 computers simultaneously.

Behind such practical concerns, though, lurks the geeks' grail: With checkers now largely conquered, will chess ever be solved? Maybe, the researchers say, but not for a long time. The possible moves in checkers, though vast, represent only the *square root* of the possible chess moves, which are something on the order of 10^{120}. (Scientists estimate the number of atoms in the known universe at only 10^{75}.) "Playing chess is like looking out over a limitless ocean," Tinsley once said. "Playing checkers is like looking into a bottomless well."

SCIENCE & TECHNOLOGY

Snows of Kilimanjaro

THE SOURCE: "The Shrinking Glaciers of Kilimanjaro: Can Global Warming Be Blamed?" by Philip W. Mote and Georg Kaser, in ***American Scientist***, July–Aug. 2007.

STARTLING BEFORE-AND-AFTER images of the retreating glacier on Tanzania's Mount Kilimanjaro in *An Inconvenient Truth*—the 2006 documentary that helped Al Gore win a share of the Nobel Peace Prize—bear seemingly convincing witness to the growing perils of global warming. As in so many instances in the global climate debate, however, the reasons why Kilimanjaro's 11,000-year-old glacier is dwindling are complex, and "bear only indirect connections, if

EXCERPT

The New Salmon Route

For ordinary humans, the extraordinary migration of salmon is difficult to imagine. Take Chinook salmon. Some of these fish swim from the Columbia River up to Canada and beyond. That would be the equivalent of a human swimming more than 160 miles a day—fast enough to circumnavigate the equator in 150 days. . . .

If the mileage clocked by these fish sounds impressive, it is nothing compared to the journeys some of them take after their death. In the case of salmon, it is all because of their pin bones—dozens of tiny bones not connected to the rest of the fish's skeleton that cannot be dealt with by filleting machines. Pin bones must be extracted by hand using tweezers or small pliers. It is a laborious process that when carried out in North America or Europe is costly. Not in China, though, with its low wages and high productivity. . . .

A typical . . . Norwegian salmon destined for sale in a supermarket in America or Europe [would pass, frozen, through Rotterdam or Hamburg, before sailing to Qingdao in China for processing by young women from rural villages]. Using nimble fingers and small scalpels, they swiftly skin the salmon, remove its bones, and cut it into the exact portions specified by a Western supermarket chain on the other side of the world. Once the fish is filleted and in pieces, it is refrozen, packed onto a ship, and sent back to Europe or the United States. By the time it reaches the supermarket, our "fresh" salmon may have been traveling for an astonishing two months.

—**SARAH MURRAY**, author of *Moveable Feasts: From Ancient Rome to the 21st Century, the Incredible Journeys of the Food We Eat*, adapted in ***Orion*** (Nov.–Dec. 2007)

any," to global warming, according to Philip W. Mote and Georg Kaser.

Tropical glaciers, such as the one on Kilimanjaro's Kibo Peak (19,340 feet) or the Quelccaya ice cap in the Andes (18,600 feet), occur when mountain summits penetrate the subzero air of the upper troposphere. Snow precipitation helps them grow; melting, usually as the result of solar radiation and light wind, and sublimation (ice converting instantly to water vapor due to dryness in the atmosphere) makes them retreat.

As Mote, a researcher at the University of Washington, and Kaser, a glaciologist at the University of Innsbruck in Austria, point out, a rise in the global temperature "fails spectacularly" to explain the disappearance of Kilimanjaro's glacier, since the air temperature at the site almost never goes above freezing. (This is not the case with the world's receding nontropical glaciers, and global warming "appears to be the primary culprit" in their decline.)

Observers have been tracking the shrinkage of Kilimanjaro's glacier ever since Europeans first scaled the peak in the 1880s, but the ice cap at that time may have been unusually large following several decades of above-normal precipitation. Judging from nearby Lake Victoria's water level, the climate in the region has gotten progressively drier since the Victorian era. Global warming may have contributed to the pattern in recent years, but that would only account for "at most a fraction of the recent decline in ice," say the authors.

Kaser, a longtime student of tropical glaciers who journeyed to Kilimanjaro in 2001, says diminished snowfall has allowed solar radiation and other forces to whittle away the glacier's edges, creating steep walls. As a result, the glacier also retains less of each year's snowfall than it did in the past. In effect, the glacier is being starved of ice.

Ironically, the authors say, "substantial global warming accompanied by an increase in precipitation might be one way to save Kilimanjaro's ice." If temperatures near the summit rose enough to encourage melting, gentler slopes might form, allowing snow to build up. An onslaught of snow might help too. The glacier could vanish, but if it does, global warming won't be to blame.

The glacier on Mount Kilimanjaro, shown in 1912 (top) and in 2006, is shrinking, but don't blame global warming. The 19,340-foot peak penetrates the upper troposphere, where the air is almost always subzero.