joint between the metatarsal and the medial cuneiform, which makes up the ball of the foot—reveals features that Tobias says almost certainly indicate time spent in the trees. "That joint, in modern humans, is remarkably flat, permitting little rotational movement," Tobias notes, "whereas in apes it is highly curved." This, he says, allows the big toe to abduct—to rotate inward like the human thumb rotates in relation to the rest of the fingers. An abductable big toe can grasp things like branches, which is a useful trait if you're frequently up a tree.

This line of reasoning is really what's up a tree, says Lovejoy. He argues that the Sterkfontein foot bones pretty much mirror what he's seen in various *A. afarensis* foot bones at Hadar—a site in Ethiopia that's produced an abundance of *afarensis* fossils—and yet when he has reconstructed the ball joint from these bones, he's found that it allows no rotation and little motion of the big toe. Therefore, he contends, the anatomically similar Little Foot would have the same constraint. Tobias, however, counters that the Sterkfontein foot bones are the first articulated bones that appear to be from a single australopithecine. Therefore, he says, information derived from them is much more compelling and illuminating than extrapolations from composites of fossils, which is how many researchers describe the Hadar bones.

Still, Lovejoy says, even if Little Foot's big toe could rotate, it wouldn't prove that the hominid actually used it as a climbing toe. "You can't expect an animal that has recently evolved bipedality to no longer have any anatomical characters that aren't also found in modern-day apes," he says.

Here Susman vehemently disagrees. If a bone is shaped to perform a task, he says, that's what it must be doing—an inactive bone will be reshaped during a single lifetime of disuse. He points, as evidence, to changes in the bones of people confined to bed for years. Because Little Foot's great toe appears well adapted to climbing, he concludes, the hominid probably did spend a good deal of time doing just that.

This, says anthropologist William Kimbel of the Institute for Human Origins in Berkeley, California, cuts to the heart of the argument, which is less about bones and more about philosophy. "What's driving most of the differences are more philosophical views about how to interpret morphology and its relationship to adaptation," he says. And until anthropologists can thrash out the issue of whether apelike bones necessarily mean an apelike pattern of locomotion, no fossil is likely to ever change any researcher's mind. Directly confronting this issue with Little Foot, he says, will be a step in the right direction.

–Lori Oliwenstein

Lori Oliwenstein is a science writer in Los Angeles.

MEETING BRIEFS

At Quadrennial Geophysics Fest, Earth Scientists Think Globally

BOULDER, COLORADO—The study of Earth is by nature a global endeavor, but only every 4 years do geophysicists come together from the four corners of the world for a general assembly of the International Union of Geodesy and Geophysics (IUGG). The 6000 scientists who gathered here for 2 weeks earlier this month had thousands of talks and posters to choose from, including two addressing a suitably international concern: ozone loss.

A Stratospheric Whodunit

Earth scientists are used to tracing far-flung connections. A calming of the trade winds in the equatorial Pacific can mean a wet winter in the southeastern United States; the eruption of a volcano in the Philippines can temporarily slow the ongoing warming of the globe.

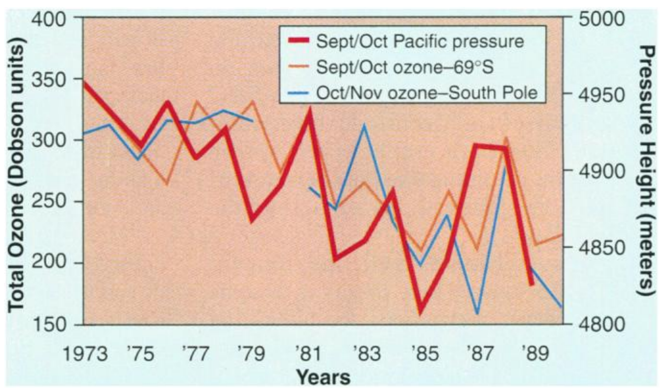
At the IUGG meeting, meteorologists Harry van Loon and James Hurrell of the National Center for Atmospheric Research in Boulder, Colorado, unveiled another long and unlikely seeming chain of connections. Their proposed linkage stretches from the warm surface of the tropical Pacific Ocean, through the atmosphere at midlatitudes in the Southern Hemisphere, to the icy stratosphere over Antarctica. And that's where it may have left its mark, by allowing a warming of the tropical sea surface 15 years ago to set the stage for the notorious Antarctic ozone hole.

Van Loon and Hurrell haven't pinned down all the links in this chain. And they have only circumstantial evidence for its involvement in ozone destruction: hints, says Van Loon, that "something drastic" happened to the chain around 1980, when the ozone hole first appeared. Other climate researchers aren't sure the chain is as long or as potent as Van Loon and Hurrell suggest. But they are intrigued by some of the individual links and say that following such connections, especially in the poorly understood Southern Hemisphere, should help tease apart the tangled threads of global change.

Clues to the connection come from records of atmospheric pressure gathered over many decades at weather stations in the Southern Hemisphere. There meteorologists long ago identified a pressure seesaw that operates on a 6-month cycle in mid and high southern latitudes. Driving the oscillation are differences in the response of the mainly ocean-covered middle latitudes and the Antarctic continent to seasonal changes in solar heating. Because atmospheric pressure differences spawn winds, this semiannual oscillation (SAO) drives changes in the strength of the vortex of winds that swirls around the Antarctic in the winter and early spring. The vortex creates the stratospheric cauldron where humanmade chemicals, icy clouds, and sunlight combine to destroy ozone.

Around 1980, Van Loon and Hurrell found, the SAO began weakening, with serious consequences, they suggest, for the stratospheric ozone over Antarctica. Meteorological data showed that the net effect of the weakening was to strengthen the Antarctic vortex in the spring and delay its annual breakup by a month or two, Van Loon says. That would have intensified the cold within the vortex and given the spring sunshine extra time to drive ozone-depleting chemical reactions—and 1980 is just when the ozone hole started to become obvious.

By the same token, when the SAO temporarily returned to near normal in 1988, weakening the vortex, the hole shriveled, registering some of its smallest ozone losses of the decade. "If I'm right," says Van Loon, the weakening of the SAO "is a necessary but not sufficient condition for the ozone hole."



SOURCE: VAN LOON, TOURPALI, AND HURRELL

Down, down, down. Springtime ozone over two sites in Antarctica started to decline around 1980, when a Southern Hemisphere pressure oscillation *(red line)* weakened, suggesting a link.

He notes that chlorine-containing chemicals trapped in the vortex were the immediate cause of ozone destruction, but he suggests that without the change in the SAO, the hole might never have appeared or might have remained shallow.

Ozone specialists, and even his co-author Hurrell, won't go that far. Even before the change in midlatitude atmospheric behavior, they say, the Antarctic vortex was sufficiently cold and long-lasting to produce an ozone hole—given enough humanmade chemicals to catalyze destruction. But the stronger vortex, says atmospheric chemist Richard Stolarski of the Goddard Space Flight Center in Greenbelt, Maryland, could have lowered the threshold by further chilling the vortex and confining the chemicals for longer. "A stronger vortex should make it easier to get an ozone depletion effect," he says, and thus bring on the hole earlier than otherwise.

The strengthened vortex could also delay the departure of the ozone hole in the mid-21st century as concentrations of ozone-depleting chemicals decline, at least if Van Loon and Hurrell are right about its ultimate cause: a warming of the tropical oceans. About the time the SAO was weakening and the ozone hole appeared, they note, the tropical Pacific suddenly warmed, and it has yet to return to normal (*Science*, 28 October 1994, p. 544). And when Van Loon and Hurrell made a longer survey of data on tropical ocean temperature and SAO strength, they found a consistent inverse correlation. They have not, however, worked out just how the influence could be transmitted from the tropical sea surface to the midlatitudes.

Murky mechanisms aside, the strengthened vortex may be here to stay if, as some other climate researchers speculate, the warming of the tropical Pacific is part of a greenhouse-driven global warming. A greenhouse-warmed climate, after all, is likely to persist for centuries. Connecting the appearance of the ozone hole to the buildup of greenhouse gases is a bold leap, even by the standards of earth science. But 25 years ago, who would have thought a puff of chlorofluorocarbons in your deodorant could wreak havoc in the stratosphere half a world away?

Sunburn Alert

Should you shop for sunscreen with a higher sun protection factor as the protective layer of ozone over most of the globe thins? It stands to reason that ozone depletion over the past 2 decades is allowing more harmful ultraviolet light (UV) to reach the surface, but because no global network of ultraviolet detectors exists to record any upward trend, scientists haven't been able to say for sure. Now the satellite-borne Total Ozone Mapping Spectrometer (TOMS), which brought much of the bad news about ozone depletion over the past 15 years, has confirmed that the news about UV is equally bad, with surface radiation in the DNA-damaging region of the spectrum increasing by as much as 12% per decade at high latitudes.

Isolated measurements at the surface had already hinted at the upward trend. So had the TOMS record of ozone loss, which is based on measurements of the increase in UV reflected back to space from the ground and lower atmosphere at wavelengths that ozone absorbs. As long as the fraction reflected from clouds and haze hasn't changed, the TOMS record should correspond to an increase in UV reaching the ground. But no one had tested that assumption until Jay Herman and his colleagues at the Goddard Space Flight Center in Greenbelt, Maryland, which operates TOMS and processes its data, reanalyzed the seventh and most thoroughly processed data set, which covers the period from 1980 to 1994.

To see whether any change in clouds and haze had altered the surface effects of stratospheric ozone loss, Herman and his colleagues examined TOMS data at ultraviolet wavelengths outside the range absorbed by ozone. Because ozone loss doesn't affect those wavelengths, they can serve as a monitor of changes in the ultraviolet reflectivity of haze and clouds. The data showed for the first time that there has been no long-term change, Herman announced at the IUGG meeting. And that adds to researchers' confidence that the increasing amounts of UV leaking through the damaged ozone shield are actually reaching the surface.

With the way open to interpreting the latest TOMS ozone loss data as an indicator of surface UV increases, Herman reported that around a latitude of 40°—over Japan, the United States, southern Europe, and New Zealand—ultraviolet light at DNA-damaging wavelengths must have increased at a rate of about 8% per decade in the spring, early summer, and autumn. At higher latitudes, the low temperatures that foster ozone loss appear to have boosted the inferred increase to 10% to 12% per decade. Only the tropics and subtropics have been spared any UV increases, Herman reported.

Sasha Madronich of the National Center for Atmospheric Research, who has extracted UV trends from TOMS data in the past, calls the new analysis "a very nice, important piece of work." Among other things, he says, it should open the way to seeing UV slow its increase as restrictions on the release of ozone-destroying chemicals take effect. And it should allow investigators to watch UV actually abate if and when the ozone layer begins to repair itself. But only TOMS will tell.

–Richard A. Kerr

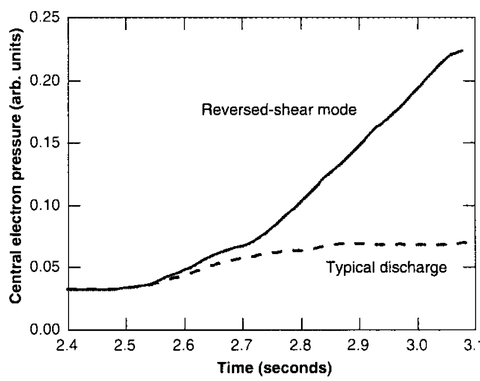
PHYSICS

Researchers Build a Secure Plasma Prison

In the halls and committee rooms of the Capitol, where the federal research budget is taking shape, the news for the U.S. fusion program has been unrelentingly bad. But in the laboratories themselves, where researchers use magnetic fields to cage hot plasma, or ionized gas, within donut-shaped vessels called tokamaks, nature is offering some encouragement. First there were the record fusion-power outputs achieved at Princeton University's Tokamak Fusion Test Reactor (TFTR) in 1993 and again late last year. Now groups at TFTR and, independently, at the DIII-D tokamak at General Atomics in San Diego are claiming a more fundamental triumph.

By tailoring the magnetic fields with unprecedented finesse, they appear to have achieved a goal that had eluded tokamak researchers for more than 30 years: taming the plasma instabilities that rattle and tear the fragile magnetic cage, allowing particles to leak out and limiting a tokamak's performance. In the process, the groups report in papers submitted to *Physical Review Letters* and presented at workshops, they increased the central density of the plasma by as much as threefold and reduced the particle leakage by a factor of 50, to "the irreducible minimum that must prevail," says Dieter Sigmar of the Plasma Fusion Center at the Massachusetts Institute of Technology. Sigmar, who is unaffiliated with either project, calls the achievement "a startling discovery that [fusion researchers] were no longer even hoping to find."

The groups are quick to caution that, so far, they have tamed the instabilities in only part of the plasma, and only in a limited range of temperatures and field strengths.



Fever line. A reversed shear field boosts the density—and hence power—of a fusion plasma.

SOURCE: PRINCETON PLASMA PHYSICS LABORATORY