present technological era and during the agricultural and hunting eras is an increase in diversity and rate of change rather than extent."

Regionally, the result of such activities is alteration of runoff, heat transport and surface winds, which in turn affect soil moisture, temperature and erosion rates. But globally, modifications in land use affect the albedo or reflectivity of the earth's surface, which in turn affects global circulation and thereby climate. All changes except urbanization increase the earth's albedo and cool the planet, say the researchers. Climate models suggest that a global albedo change of 0.01 from its value of 0.30 will produce a surface temperature change of about 2°K. Sagan and coworkers estimate the global albedo change of the "past few millennia" at 6 x 10^{-3}, which is enough, they say, to drop the world's temperature by about 1°K. By contrast, they estimate the global albedo change for the last 25 years at 1 x 10^{-3}, an amount that suggests a global cooling of about 0.2°K. (According to the researchers, the global average temperature has dropped 0.2°K since 1940, even with the effect of CO_2.)

The leading cause of the change in global albedo is desertification, say the researchers. They estimate that 9 million square kilometers, or 1.8 percent of the earth's area, has been changed by humans to desert by overgrazing or other destruction of vegetation or overpopulation. Altering that much of the earth's surface has caused a 4 x 10^{-3} change in global albedo. Areas given over to desert by human hand include the Rajasthan Desert of India, the Sahel south of the Sahara, Lebanon and parts of Iraq.

Clearing of tropical forests has altered 7 million square kilometers; that of temperate forests has altered 8 million square kilometers. The resulting albedo change is 1 x 10^{-3} and 6.5 x 10^{-4}, respectively. Deforestation, the researchers suggest, may have been responsible for the extreme cold period in the Northern Hemisphere known as the Little Ice Age (1430 to 1850). A fourth process, salinization, changes albedo by exposing bare ground and by creating salt flats. It has affected 600,000 square kilometers and changed albedo by as much as 4 x 10^{-4}.

But none of this lets modern humans off the hook. For example, continued deforestation — particularly that occurring in the Amazon — may pose a major global climate threat, the researchers suggest. Satellite studies of global land usage and studies of historical land modifcation are needed, they say. "We believe that the effects of humans on both ancient and modern climates are not insignificant in comparison with other causes of climate change. ... Such work holds the promise not only of elucidating past climate changes and their possible human origin, but also of providing insight into the climate of the future." □

A solid twist for accelerator beams

Particle physics and solid state physics often collaborate. The beams of accelerated protons, electrons, and such that particle physicists use to study the nature and structure of subatomic particles can also be used to study the structure of solids. To a proton or an electron a solid is mostly empty space, and sometimes when the particle beams hit the crystals they go right through.

This transparency phenomenon, called channeling, is being investigated for its possible advantages to both branches of physics by a team of researchers led by Timothy E. Toohig and Richard A. Carrigan of the Fermi National Accelerator Laboratory at Batavia, Ill., and Edward Tsyganov of the Joint Institute for Nuclear Research at Dubna, 70 miles north of Moscow. It will be the first example of United States physicists going to the Soviet Union to do experiments since 1970.

Channeling takes place in extremely perfect crystals, which have a precisely regular array of atoms. This regular array leaves unobstructed channels between planes of atoms. Particles that enter the channels in the right way are constrained to move along them by the forces exerted on them by the atoms in the walls of the channels. And so the particles go right out the other side of the crystal.

Experiments done at Fermilab's Meson Laboratory and at Dubna showed that channeling was indeed an actual phenomenon. It then occurred to Tsyganov to see what would happen if the perfect crystal were carefully bent. Would the particles follow the curve of the channel or would they blast out the side of the crystal at the curve? He found out that the particles follow the curve.

If this curving phenomenon works at higher energy, it could be very useful in the technology of particle accelerators. "Calculations show that by using crystals in certain applications, we can bend high energy beams by a factor of about 1,000 more than by use of conventional magnets," says Toohig. When accelerators get to the trillion electron-volt energy range, he says, a crystal a meter long could be used for "promising applications in certain parts of accelerators." One such part is the touchy business of extracting beams from accelerators to send them to experiments some distance away. A septum consisting of an array of wires is now used to deviate the beam. A crystal in that place could exert stronger bending forces on the particles. It should also wear better. "If we lose beam on them [the wires], we cut them away like butter," says Toohig.

The high energy experiments will be done at Serpukhov, another physics research center in Russia. The international collaboration was chosen because it seemed efficient to pool material and intellectual resources, especially since the Soviets had perfect crystals readily available, some of which were made in the Salyut space station. Serpukhov is the site of the most powerful Soviet accelerator, a proton synchrotron of 70 billion electron-volts energy. Toohig plans to leave for Serpukhov early in the year. There, he says, in addition to the channel bending, "we plan to explore other aspects of this fascinating marriage between high energy physics ad solid state physics." □

Ozone: Worldwide, many-faceted problem

Only international efforts will be able to protect stratospheric ozone against depletion by chlorofluorocarbon emissions, according to the second part of a National Academy of Sciences study. The first part (SN: 11/17/79, p. 340) concluded that if worldwide use of the chemicals continues at current rates, stratospheric ozone will be depleted by 16.5 percent (twice the previous estimates) by late in the next century. The NAS committees say that a "wait and see" approach is not feasible; the United States should take the lead in initiating an international program for control of chlorofluorocarbons.

"Whatever happens, it happens worldwide," John W. Tukey of Bell Laboratories and Princeton University told reporters. The United States now produces less than half of the world's chlorofluorocarbons, since the ban on nonessential use of the chemicals in aerosol spray propellants (SN: 5/21/77, p. 324). "We have shown the way," Tukey says. "It really wasn't very difficult to get rid of them [the propellants]." However, few other countries have followed suit.

Aerosols, although a major source of emissions, are not the whole problem. The NAS report points out that chlorofluorocarbons are being used in more and more industrial processes, and regulators should consider steps to control other uses. Even if chlorofluorocarbon use as aerosol propellants was eliminated in all countries, nonpropellant uses are growing so rapidly that within ten years they alone could produce the current level of total chlorofluorocarbon emission. Tukey says, "We are now at the place where no one thing, other than banning aerosol propellants, is going to make a vital change. We have to go onto several fronts, many fronts."

Today major emitters of chlorofluorocarbons in the United States are automobile air conditioners, manufacture of plastic foams (such as for cushions or packing material) and industrial processes for cleaning metals. Other chlorofluorocar-