Fickle climate thwarts future forecasts

Researchers trying to predict the side effects of future climate change are finding themselves the modern-day heirs of Sisyphus, straining toward a goal that forever slips out of reach. A new projection of conditions in Europe for the year 2050 indicates that natural shifts in climate can greatly complicate the forecasting task and will make it nearly impossible in some cases to tell whether greenhouse warming is having any clear effect.

"We can only interpret the significance of human-induced climate change if we understand the magnitude of the naturally induced changes. That's what we're doing," says Mike Hulme from the University of East Anglia in Norwich, England.

In past assessments of this type, researchers have attempted to forecast agricultural production and other factors by comparing current conditions against simulations of the future. Such an approach assumes that Earth's climate would otherwise remain constant. "I think there's some major weaknesses in stuff that's been published in the past," says Hulme.

He led a team of British scientists that attempted to develop a more sophisticated approach. They started with a computer model that simulates the global effects of adding greenhouse gases to the atmosphere. In one scenario, they assumed that carbon dioxide amounts would grow by 1 percent per year. In another, they assumed half that rate. A third run, with carbon dioxide constant, simulated natural climate variation alone.

The outcomes from these different simulations then went into one model that predicts wheat yields and another that gauges the amount of water in rivers. The researchers assessed how the effects from greenhouse warming measure up against the natural variations that always occur.

The modeling study, published in the Feb. 25 NATURE, suggests that human-caused climate change will noticeably increase river runoff in northern Europe and decrease it in southern Europe by the year 2050. But in central and western Europe, the predicted changes will not exceed the range of natural fluctuations.

Wheat yields in Finland, Germany, and the Netherlands will increase by significant amounts, but the results for other countries do not stand out above nature's inconstancy. The forecasts for all countries go up markedly—by 9 to 39 percent—when the researchers factor in the fertilizing effect of additional carbon dioxide in the air. They did not include other potential complications, such as changes in pests, or the abilities of farmers to improve fertilizers and crops.

Some researchers warn against placing faith in this specific forecast. Cynthia Rosenzweig of NASA's Goddard Institute for Space Studies in New York City says that most crop forecasts and similar studies use results from several global climate models to guard against peculiarities of any one model. What's more, the impact of global warming will become more obvious after 2050, she says.

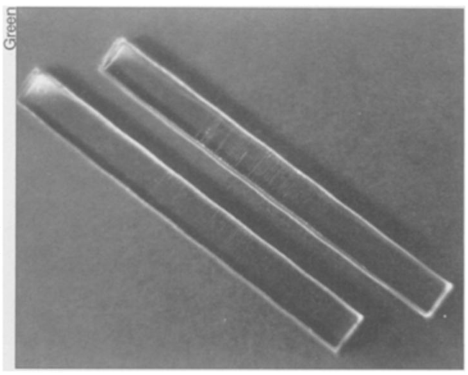
Rosenzweig and others agree that scientists need to consider climate variability in a more sophisticated way than they have in the past—a lesson already being incorporated into the U.S. effort to assess the effects of natural and human-caused climate change. "One has to be looking at the impacts of climate change in the context of all the other things that are happening," says Michael MacCracken, director of the National Assessment Coordination Office in Washington, D.C.

The new British study fits into a growing awareness that climate can undergo decades-long natural swings, with occasionally harmful consequences. "There's an awful lot we should be doing to adapt to current climate variability, and if we properly adapt to that full range of natural variability, then we'll actually be in a better position later on in the next century to withstand anything that human-induced climate change will throw at us," says Hulme. *—R. Monastersky*

Tempered glass can bend before it breaks

When struck, a car window doesn't just crack, it shatters into tiny, rounded, harmless pieces. The glass undergoes this dramatic failure because it's tempered with heat. Tempering makes glass very strong, but as soon as a crack starts, the glass breaks into smithereens.

Now, David J. Green of Pennsylvania State University in State College, Rajan Tandon of the Caterpillar Technical Center in Peoria, Ill., and Vincenzo M. Sglavo of the University of Trento in Italy have developed a way to temper glass chemically so that it can withstand some cracking before ultimately shattering. "This is very useful," Green says. "It gives you a bit of warning before failing."



Glass tempered by a new process doesn't shatter immediately under stress. Instead, many tiny cracks form on the surface, then stop at a given depth.

What's more, the strength of the new glass is much more predictable than that of ordinary tempered glass. The strength of conventionally treated glass can vary from one piece to the next by as much as 20 percent from the average. The strength of the new glass, however, deviates just 2 percent.

This precision opens up new applications for ceramics, including glasses, says S. Jill Glass of Sandia National Laboratories in Albuquerque, N.M. "Designers of different products have been reluctant to use ceramics because they can't predict exactly when [the materials] will break," she says. Engineers often overdesign a product for safety, making the components needlessly thick and heavy.

All tempered glass derives its high strength and its tendency to shatter explosively from the forces between its atoms. Those on the outer surface crowd together while those deeper in the glass remain free of stress. Defects cannot easily break through that outer layer, so only a very strong blow can initiate a crack. Release of the stress triggers the spectacular breakage.

Green, Tandon, and Sglavo figured that changing this internal stress profile could alter the way the glass splits apart. They compressed the atoms about 25 micrometers below the surface, where they could act as a barrier to block the propagation of cracks starting at the surface.

The researchers accomplished this by tempering pieces of sodium aluminosilicate glass with a two-step chemical process. First, they exchanged some of the sodium ions in the glass for potassium ions. The larger potassium ions stuff themselves into the spaces vacated by sodium, producing compressive stress in the glass. Then the researchers resubstituted sodium ions in the surface layer only, leaving a tempered layer just below the untempered skin.

When the treated samples are bent, many tiny cracks appear in the skin, run down to the barrier, and stop. The cracks build up until the glass finally shatters into small fragments. This delayed shattering is very unusual in a brittle material, Green says. The team describes its findings in the Feb. 26 SCIENCE.

Because the technique is relatively expensive, Green says, "it probably won't take over the field, but it will have applications." Electronic components might be the first products made with these materials. Also, valves designed to burst open at a certain pressure could make use of these glasses, says Glass. Green is unsure whether the process could be used on car windows and windshields, since they are tempered with heat rather than chemicals. *—C. Wu*