CLIMATE PREDICTION

Seasonal-Climate Forecasts Improving Ever So Slowly

Farmers, ski-resort operators, and heating-oil suppliers would very much like to know what the coming winter will be like. If a strong El Niño were brewing in the tropical Pacific, at least some of them would be in luck. The official United States winter forecast could warn them, with considerable reliability, that the Southeast and the Gulf Coast will be cooler and wetter than normal. But without an El Niño or its counterpart, La Niña, next winter's weather is pretty much anybody's guess.

Of the dozens of forecasting techniques proffered by government, academic, and private-sector climatologists, all but two are virtually worthless, according to a new study. "There are seasons, places, and situations in which skill is very, very good," says climatologist and study co-author Robert Livezey, recently retired from the National Weather Service (NWS). But even many people in the field "don't appreciate how little there is to work with. There is really no evidence here that there are any other silver bullets" waiting to be found.

Since 1946, NWS forecasters have been trying to forecast the average temperature and precipitation across the lower 48 states a month ahead, and more recently season by season up to a year ahead. At NWS's Climate Prediction Center (CPC) in Camp Springs, Maryland, where Livezey oversaw seasonal forecasting in the late 1990s, the trick has generally been to identify some element of recent or current climate—say, the presence of El Niño—that can influence future climate. If they couldn't find one, researchers could fashion a forecast "tool"—such as a collection of past time periods when the climate system resembled the current situation—that when tested on past seasons gave some inkling of future seasons. They would then subjectively choose which techniques to combine and how to combine them in order to predict whether temperature and precipitation would be above, near, or below normal in some 3-month period in a particular region.

The CPC approach has shown very modest though increasing skill at CPC, Livezey and climatologist Marina Timofeyeva of NWS in Silver Spring, Maryland, report in the June issue of the *Bulletin of the American Meteorological Society*. They worked up a scorecard for CPC forecasts made from 1994 to 2004, comparing the success rates for different seasons, regions, and periods when a strong El Niño or La Niña was present or absent.

About the only time forecasters had any success predicting precipitation was for winters with an El Niño or a La Niña, Livezey and Timofeyeva found. Using a scale in which mere chance is 0% and perfection is 100%, in those winters they estimate "unprecedented" skill—50% to more than 85%—along the southern tier states and up the West Coast about half a year into the future. Even so, the overall skill score for precipitation was just 3%.

Temperature forecasts fared better, with an overall skill score of 13%, up from a score of 8% for the previous decade. El Niño and La Niña helped out again during winter, raising skill to more than 85% across much of the eastern United States out to more than 8 months. But CPC also had substantial success predicting temperature out to a year in the American

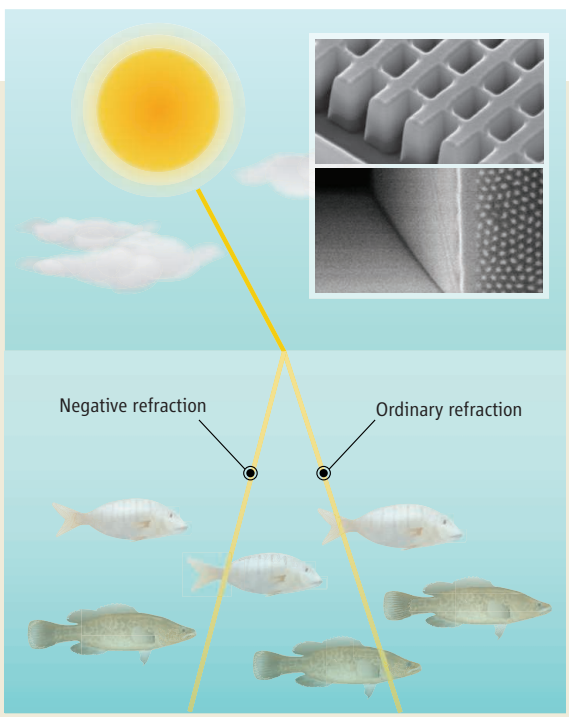
APPLIED PHYSICS

Bizarre 'Metamaterials' for Visible Light in Sight?

When, in 2000, physicists unveiled the first "left-handed metamaterial"—an assemblage of metallic rods and rings that interacted with and bent microwaves in strange ways—physicists immediately knew they had a grand goal to shoot for: miniaturized metamaterials that would bend visible light in the same way. If such things could be made, they could result in wild devices, such as a "superlens" that would focus light tighter than any conventional lens. Metamaterials might be used to make invisibility cloaks, too, researchers have since shown. Now, metamaterials for visible light may be within reach, thanks to advances reported this week online in *Nature* and on page 930 of this issue of *Science*.

Both results come from the lab of Xiang Zhang, an applied physicist at the University of California, Berkeley. In *Nature*, Zhang's team describes a metamaterial that works for near-infrared light and, unlike previous materials, is three-dimensional. In *Science*, the team presents a different three-dimensional metamaterial that bends visible red light in the desired way.

Opinions vary as to how substantial the advances are. "With the *Science* paper, we are really very, very close" to applications with visible light, says Costas Soukoulis, a physicist at Iowa State University in Ames and the Department of Energy's Ames Laboratory. But Henri Lezec, an electrical engineer at the National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland, says "the claims are misstated and overhyped."



Kinky. A metamaterial full of holes (top inset) bends infrared light in an unusual way. Another full of silver nanowires (bottom inset) works in the visible.

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Metamaterials put a kink in the way light usually passes from one medium into another. Suppose light from the setting sun

Published by AAAS

Spot on. Forecasters nailed California's 1997–'98 winter forecast thanks to El Niño.

West outside of El Niño–La Niña years, thanks to the long-term greenhouse warming trend picked up by one of the forecast tools.

Because a strong El Niño or La Niña shows up only every few years, his results paint "a kind of discouraging picture" of seasonal forecasting, Livezey says: "You can probably find dozens of forecast [techniques] people use to give themselves an edge. Almost all of that is mumbo jumbo." CPC forecasters have done well to make their forecasts more objective in recent years, Livezey and Timofeyeva write; CPC should weed out remaining weak forecast tools and focus future research on computer model forecasting of climate months ahead.

"This is a very tough business," agrees CPC's head of forecast operations, climatologist Edward O'Lenic. But he says Livezey and Timofeyeva's analysis of past skill "does have some flaws" that make it underrate CPC's performance, and he thinks some of the forecast tools they dismiss may still prove useful in ways researchers don't yet understand.

Climatologist Anthony Barnston of Columbia University's International Research Institute for Climate and Society in Palisades, New York, leans toward what he calls O'Lenic's "philosophical" preference for being more inclusive of forecasting tools. But Barnston agrees with Livezey that modeling holds the greatest promise for improving seasonal forecasting. **–RICHARD A. KERR**

shines on a pond. As light waves strike the surface, their direction will change so that they flow more directly down into the water. (See diagram.) Such "refraction" arises because the light travels more slowly in water than in air, giving water a higher "index of refraction." Still, the light continues to flow from west to east. Were water a left-handed metamaterial, however, "negative refractions" would bend the light back toward the west.

To produce the effect for near-infrared light, Zhang, Jason Valentine, and colleagues created a material that looks like a miniature waffle. They laid down 21 alternating layers of conducting silver and insulating magnesium fluoride on a quartz substrate and drilled holes in the stack using an ion beam. They cut the stack at an angle to make a prism and showed that it bent light the "wrong" way compared with an ordinary prism. To achieve negative refraction in the visible range, Zhang, Jie Yao, and the team used a standard electrochemical technique to make a sample of aluminum oxide filled with a regular array of nanometer-sized holes, which they filled with silver. When they shined red light onto the sample at an angle, it underwent negative refraction.

That might seem to seal the deal, but not everyone is convinced. Lezec argues that the infrared metamaterial isn't truly three-dimensional because it works for light coming from only a narrow range of directions. The metamaterial that bends visible light works for light of only a single polarization, he notes. And all agree that, strictly speaking, it does not have a key property—a negative index of refraction—although the infrared metamaterial does.

That's nitpicking, says Vladimir Shalaev, a physicist at Purdue University in West Lafayette, Indiana. "What's wrong with [using] a particular polarization?" he says. "As a first step, it's not so bad." The real advance in the *Science* paper may be a new self-organizing approach to fashioning the materials, Shalaev says. Soukoulis warns that researchers must confront a basic problem: At shorter wavelengths, metamaterials absorb far too much light. For now, however, the future for metamaterials looks particularly bright.

–ADRIAN CHO

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SCIENCESCOPE

The Stars Are Out in China

BEIJING—China is building a new set of ears tuned to our nearest star. Last month, the government of Inner Mongolia provided land to the National Astronomical Observatories of the Chinese Academy of Sciences for the Chinese Spectral Radioheliograph (CSRH), one of two major ground-based solar instruments that China's scientific community plans for the coming decade. Construction will begin later this month on the $7.3 million facility, which will listen in on radio bursts that could presage coronal mass ejections and solar flares. When directed at Earth, these ionic tidal waves can trigger geomagnetic storms that disable satellites and knock out power grids. Set to open in 2010, CSRH will consist of 40 radio dishes, each 4.5 meters wide. They will be clustered on the steppe in a zone devoid of earthly radio waves—apart from stray cell phone signals—260 kilometers northwest of Beijing.

Meanwhile, there's work on a complementary facility, the Frequency-Agile Solar Radiotelescope (FASR). In June, the National Radio Astronomy Observatory (NRAO) and several university partners asked the U.S. National Science Foundation for $25 million to build FASR at Owens Valley Radio Observatory in California. If they receive the funds, the consortium wants to begin building a prototype array at Owens Valley next year, says NRAO's Tim Bastian. **–RICHARD STONE**

Changes to Species Law Draw Fire

The U.S. Department of the Interior has proposed loosening rules controlling how the government follows the Endangered Species Act in building and permitting highways, dams, and other projects. Currently, federal officials must consult scientists in the U.S. Fish and Wildlife Service or National Oceanic and Atmospheric Administration if the proposed projects "may" affect endangered species. Under the changes, officials would ask for consultations only if they "anticipated" impacts on threatened species. The Administration says the changes will reduce paperwork so that "more time and resources can be devoted to the protection of the most vulnerable species." But former U.S. Forest Service ecologist Robert Mrowka, now with the Tucson, Arizona–based Center for Biological Diversity, says the rules are "like the fox guarding the hen house" and remove independent scientists from the review process. **–ELI KINTISCH**

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