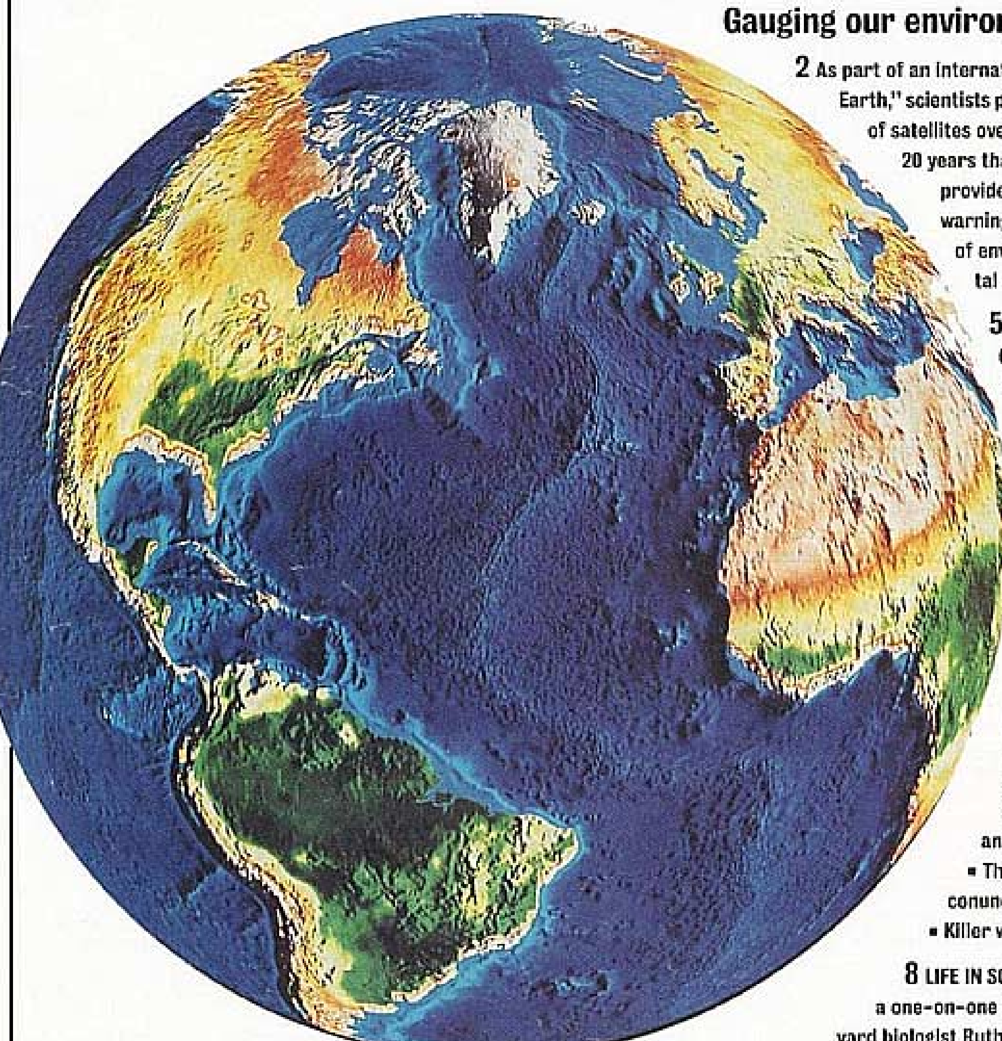
Newsweek

FOCUS

SCIENCE & TECHNOLOGY

EYE ON EARTH

Gauging our environmental health



2 As part of an international "Mission to Planet Earth," scientists plan to send up an armada of satellites over the next 20 years that could provide early warning signs of environmental crisis.

5 UNDERWATER TURMOIL: Overfishing doesn't just make it harder to catch tuna and cod. It can undermine an entire ecosystem.

6 BRIGHT NEW IDEAS:
- Harnessing electric power to make fertilizer out of thin air.
- A dye that changes color with the touch of a button.

7 LAB NOTES:
- When bats mate—and why.
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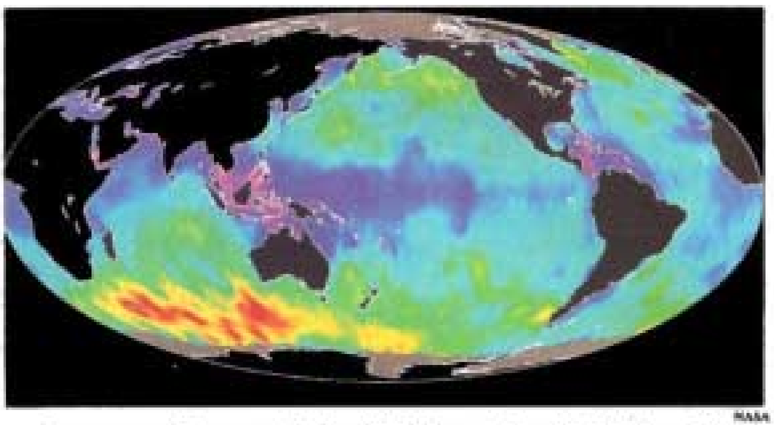
8 LIFE IN SCIENCE: In a one-on-one interview, eminent Harvard biologist Ruth Hubbard warns against society's misuse of genetics.

CLOCKWISE FROM ABOVE: NASA, DAVID DUGGINS, MERLIN D. TUTTLE – PHOTO RESEARCHERS

Looking Homeward

By ROBERT F. SERVICE



NASA

Stormy seas: Waves up to 26 feet high show up in red in this view of the earth's oceans charted last year by the TOPEX/Poseidon satellite

WITH LITTLE FANfare, in September 1991 the Space Shuttle Discovery dispatched a 7.5-ton electronic behemoth called the Upper Atmosphere Research Satellite to keep an eye on earth's battered ozone layer. Within months, UARS sensors revealed that ozone-depleting chemicals were amassing over North America and Europe. Newspapers pounced, predicting that ozone levels would plummet and exposure to the sun's ultraviolet rays would rise, thereby causing skin cancer in as many as 300,000 people. The Senate responded by voting 96-0 to force chemical manufacturers to speed up the phase-out of ozone-depleting chemicals called chlorofluorocarbons. When follow-up readings showed that winter's ozone levels down only 10 percent, critics charged that fear of an ozone hole over the Northern Hemisphere was a lot of hype. Ozone researchers fired back that they never said a precipitous drop in ozone was certain.

Satellites rarely spark such controversy. But the UARS flap may be a harbinger of squabbles to come as nations turn to an armada of scientific satellites to assess the planet's environmental health. In a series of joint and solo missions, the United States, Japan and several European countries plan to launch more than 50 environmental satellites over the next 10 years. For its part of this "Mission to Planet Earth," NASA has more than two dozen satellites on the drawing boards. Most of these are part of what NASA calls its Earth Observing System (EOS), which will focus primarily on scientific uncertainties surrounding global warming. Other satellites, like UARS, are designed to study equally perplexing scientific riddles, such as ozone chemistry and ocean-circulation patterns. All this information won't come cheap. EOS satellites alone, which NASA plans to launch between 1998 and 2013, are expected to cost $8 billion to build, launch and maintain just through the year 2000.

Until now, understanding earth's climate patterns has been like trying to follow the plot of "War and Peace" by reading a few random paragraphs. Ground-based measurements provide accurate local readings of temperatures, cloud cover, wind speeds and ocean currents. But climate modelers trying to stitch these fragments into an overall view of the planet's climate are left with large gaps in their understanding of how different parts of the system affect each other. If rising greenhouse gases like carbon dioxide and methane raise global temperatures 3 to 8 degrees Fahrenheit over the next century, as predicted, will that cause droughts in Kansas and floods in Bangladesh? Or will warmer temperatures raise evaporation rates and make more clouds, thereby causing more sunlight to be reflected into space and offsetting greenhouse warming?

More than 20 electronic sensors on six models of EOS satellites will try to find the answers. With names like MODIS and TES, these sensors will take precise measurements of more than 800 variables —everything from cloud height and thickness to patterns of ocean circulation (diagram). Since the satellites have a life span of only three to five years, NASA intends to launch successive waves of each model to keep the data coming in for 15 years. That, the space agency hopes, will give scientists the long-term view of climate change they need to refine their models and sharpen their predictions. "That's where satellite measurements really score big," says Carl Reber, a senior scientist on Mission to Planet Earth at NASA's Goddard Space Flight Center in Greenbelt, Md. "They can give you large-scale measurements over a long period of time."

The role of clouds: One of the first things EOS sensors will try to answer is how clouds affect global warming. Clouds confound climate modelers because they play a dual role in regulating the planet's temperature. By reflecting sunlight back into space, they cool the globe; by preventing surface heat from escaping, they warm the planet. Whether a cloud has a net heating or cooling effect depends on, among other things, its shape, how much water it holds and how high it floats.

To gather this range of detail, EOS sensors will chart the visible, infrared and microwave signatures of clouds. Like everything else, clouds reflect and absorb particular wavelengths of light depending on their chemical makeup. By recording things like a cloud's color and temperature, sensors help scientists determine this chemical makeup and other properties, such as shape and water content. No single sensor is adept at making all these measurements, says Michael King, EOS senior scientist at Goddard, so the satellites mix and match different sensors to get the full picture. Visible light reveals patterns of cloud distribution; infrared sensors penetrate the surface of clouds to determine their water content; microwaves shine clear through to gauge their thickness.

Ocean circulation: Another climatic mystery is the complex role the world's

Taking the Earth's Temperature

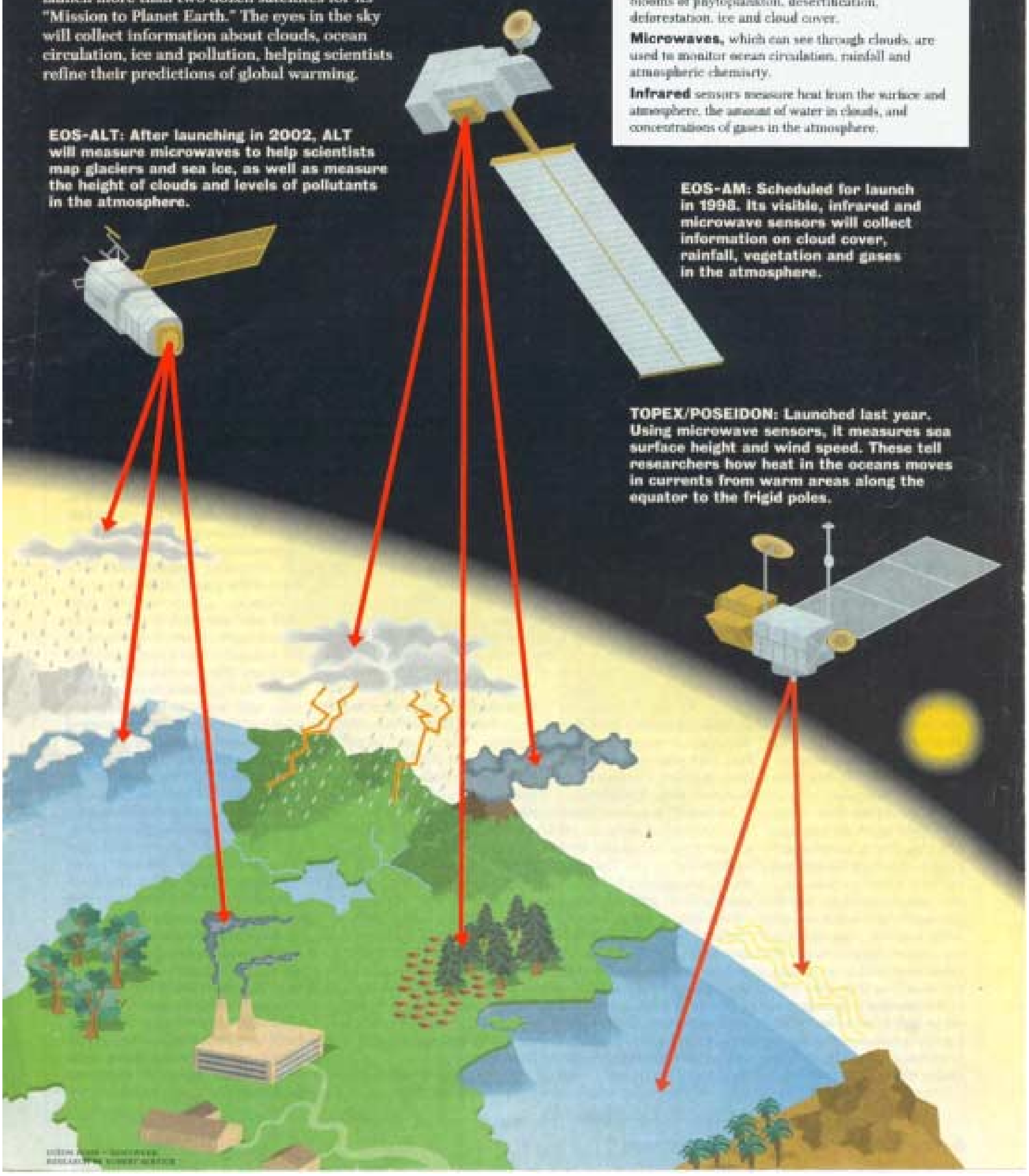
Over the next two decades, NASA plans to launch more than two dozen satellites for its "Mission to Planet Earth." The eyes in the sky will collect information about clouds, ocean circulation, ice and pollution, helping scientists refine their predictions of global warming.

Earth-gazing satellites typically fly with several sensors that monitor different parts of the light spectrum. Each wavelength yields its secrets.

Visible light reveals information about ocean blooms of phytoplankton, desertification, deforestation, ice and cloud cover.

Microwaves, which can see through clouds, are used to monitor ocean circulation, rainfall and atmospheric chemistry.

Infrared sensors measure heat from the surface and atmosphere, the amount of water in clouds, and concentrations of gases in the atmosphere.



oceans play in regulating global temperatures and wind patterns. Oceans not only absorb carbon dioxide and other greenhouse gases from the atmosphere but also hold and transport vast amounts of heat through a network of currents. Some scientists suspect that changes in ocean circulation may have led to sudden, dramatic climate shifts in the past. In turn, some computer models suggest that changing temperatures and wind speeds in a greenhouse world could affect such currents in the future, according to Lee Fu, project scientist for the TOPEX/Poseidon satellite at NASA's Jet Propulsion Laboratory in Pasadena, Calif. The joint French-U.S. satellite, launched last year, charts ocean-circulation patterns and wind speeds. By bouncing microwave pulses off the sea surface and recording how long it takes them to return, the satellite charts sea surface height to within roughly two inches. Using this information, scientists are able to chart ocean currents worldwide. In February, TOPEX scientists used such readings to successfully track an extension of the Pacific Ocean current known as El Niño, which in the past has caused billions of dollars in damage by triggering floods in the southwestern United States and droughts in Asia and Australia.

NASA

Colored Amazon: Landsat image shows deforestation (light blue) and forest (orange)

Yet another unknown for climate modelers is the precise role of living organisms in regulating climate. From giant redwoods in California to phytoplankton in the ocean, all plants absorb carbon dioxide from the air to build their cells. Some scientists suspect that a climate richer in CO_2 may help some plants grow faster (page 7), while others contend that a warmer globe may rob plants of vital water by increasing evaporation rates on land. To sort out these competing effects, EOS satellites will use visible and microwave sensors to spot slight changes in the color of ocean plankton and other vegetation for hints on their health and productivity.

Start making sense: All this information beaming down from space will give scientists a very different problem. By 2002, earthbound computers will be besieged by as much as one terabyte (1,000 billion bits) of information from the satellites every day—that's enough to clog the hard drives of 10,000 average-size personal computers. Making sense of it all will be like trying to take a drink of water from a fire hose. NASA plans to set aside one quarter of its EOS budget for the EOS Data and Information System. Researchers around the world will access this databank to integrate the cloud patterns and soil-moisture and ocean-circulation measurements into their computer models, and come up with refined predictions of the greenhouse future.

Whether Congress will fund EOS and the rest of Mission to Planet Earth remains to be seen. In the wake of NASA's recent botched missions, like the mute Mars Observer, NASA's congressional enemies are sure to lambaste the massive project as more science pork. Congress has already slashed $9 billion from the space agency's original 1991 EOS budget of $17 billion. Thus far NASA has been able to retain most of the instruments designed to measure global warming. But if Congress demands further cuts, agency officials claim, hardware designed to measure things like the mass of glaciers and sea ice may have to be dropped. "If we have to downsize any further, it would mean seriously limiting the scientific themes we can address," says Robert Price, director of the Mission to Planet Earth office at Goddard. It would also leave NASA with the image of being willing to explore the depths of outer space while ignoring our own backyard. ■

The Comeback of a Crop Doctor?

Even plants can run a fever, especially when they're under attack by insects or disease. But unlike humans, plants can have their temperature taken from 3,000 feet away—straight up. A decade ago, adapting the infrared scanning technology developed for military-reconnaissance and other satellites, physicist Stephen Paley came up with a quick way to take the temperature of crops to determine which ones are under stress. The goal was to let farmers precisely target pesticide spraying rather than rain poison on a whole field (which invariably includes plants that don't have pest problems). Even better, Paley's Remote Scanning Services company could detect and pinpoint incipient crop problems before they became visible to the eye.

Mounted on a plane flown at 3,000 feet at night, an IR scanner measured the heat emitted by crops. The data were transformed into a color-coded map showing where plants were running "fevers." Farmers could then spot-spray, using 50 to 70 percent less pesticide than they otherwise would.

The bad news is that Paley's company went bankrupt in 1984, after only three years. Farmers resisted the new technology and long-term backers were hard to find. But with the renewed concern about pesticides on produce, and refinements in IR scanning, Paley hopes to get back into operation. Agriculture experts have no doubt the technology works. "This technique [can be used on] 75 percent of agricultural land in the U.S.," says George Oerther of Texas A&M. Ray Jackson, who recently retired from the Department of Agriculture, thinks remote infrared crop scanning could be adopted by the end of the decade. But only if Paley finds the financial backing that eluded him 10 years ago.

■HEIDI SCHULMAN