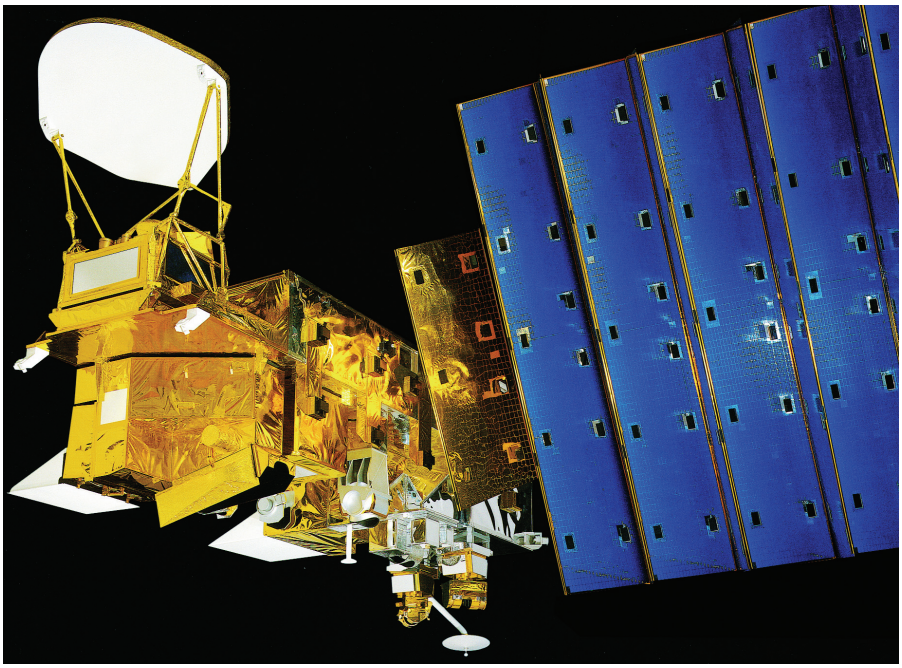
Global Earth Observations for Health

Every day, Earth-observing satellites outfitted with remote-sensing technology generate vast data streams that scientists use to study the biosphere—the part of the Earth and its atmosphere that can support life. These orbiting systems are rapidly advancing studies of climate change, weather, and other global phenomena. Now experts are looking for ways to put them to work in the field of environmental health research.



Eyes in the sky. Earth-observing satellites such as Aqua (above) are being used to monitor problems including air pollution, weather, and climate change. A recent meeting at the NIEHS brought together scientists from a broad range of disciplines to discuss how satellite data might be brought to bear on addressing issues of human health.

Recently, the NIEHS and the U.S. Environmental Protection Agency (EPA) united health and Earth scientists in a workshop charged with two key objectives. The first was to determine if observations of air quality and climate from space could be used as public health tools for research, policy decisions, and environmental and health planning. The second was to engage the NIEHS extramural research community in dialogue with remote-sensing data producers and organizers including the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, and the EPA. Together these experts explored ways to use Earth observation data in studies of air pollution and health.

The NIEHS and Earth Observations

The workshop, titled "Global Earth Observations: Application to Air Quality and Health," was held at the NIEHS campus on 1–2 August 2005, and was attended by several dozen academic and government scientists. "Health researchers already use ground-based measurements of air pollution [to assess human exposures], and the workshop provided a mechanism for them to consider if addition of remote-sensed data would improve their exposure assessment and analysis of disease outcomes," says Sally Tinkle, a program administrator with the Cellular, Organs, and Systems Pathobiology Branch of the NIEHS Division of Extramural Research and Training. Tinkle, together with NIEHS program analysts Mary Gant and Mike Humble and EPA representatives Gary Foley, Valerie Garcia, and Andy Bond, organized the event and provided NIEHS scientific support.

The NIEHS plays a growing role in the use of this technology, in part through its membership in the U.S. Group on Earth Observations (USGEO), a standing committee that reports to the National Science and Technology Council's Committee on Environment and Natural Resources. The USGEO recently drafted a 10-year strategic plan for applying Earth observations to health and environmental research, which was released by the White House on 6 April 2005. Tinkle is the NIEHS's USGEO representative, and Gant leads the USGEO's User Interface Working Group.

At the August workshop, speakers covered issues ranging from the strength and adequacy of remote-sensing data to new directions in satellite research, coverage with land-based monitoring networks, and the challenges of using spatial data to address air quality and health outcomes. Participants also split into working groups to identify potential demonstration projects for remote sensing in three areas of health research: respiratory disease, cardiovascular disease, and developmental biology. Outcomes in all three areas have been linked to air pollution.

An Emphasis on Feasibility

Despite an initial focus on user needs in the area of remote-sensing data architecture—the way data are organized, stored, and made available to users—the workshop dialogue shifted frequently to feasibility issues. While the health scientists present found the technology intriguing, they raised questions about its potential for human exposure assessment.

Resolution limits were of particular concern. Remote sensing's spatial resolution, for instance, is rarely less than a square kilometer, although there is increasing evidence that air pollution levels vary at much finer scales of resolution (for instance, city blocks). Temporal resolution can also be problematic, especially for polar-orbiting satellites, whose positions remain fixed as the Earth rotates beneath them (this is less of a problem for geostationary satellites, which orbit in sync with a particular location and thus image that area all the time).

Discussions also addressed methods for averaging pollution concentrations measured from space. Remote sensors measure pollution in atmospheric columns that extend to the outer edge of the stratosphere. Humans, however, are exposed to pollutants close to the Earth's surface.

Finally, participants discussed limits on remote particulate measurements, which don't extend below the 10-micron level and cannot distinguish between chemical species on particle surfaces. "All these factors contribute to the uncertainty of linking remote-sensing data to human effects," says workshop participant Raymond Hoff, a professor of physics at The University of Maryland, Baltimore County.

NASA

According to Tinkle, feasibility discussions exposed the need for demonstration studies that layer remote-sensing data over existing ground-based pollution data sets. "This would permit us to determine if the addition of remote-sensing data improves the correlation of air pollution with adverse health events—such as asthma exacerbation and myocardial arrhythmias, for instance—in the area of respiratory and cardiovascular disease," she says.

Working Group Conclusions

Peggy Reynolds, an investigator with the Environmental Health Investigations Branch of the California Department of Health Services, moderated the working group on respiratory disease. During breakout sessions, participants identified key data needs in this area. They included improved measures for data quality assurance and control, validated correlations with health outcomes, and confirmation that remote-sensing data accurately represent exposures on the ground. Participants speculated that remote sensing could help fill gaps in existing exposure data and suggested a demonstration project that correlates asthma prevalence with remote-sensed measures of airborne particulates and bioallergens.

Diane Gold, an associate professor at the Harvard University School of Public Health, moderated the cardiovascular disease working group. Participants in this group identified "applications," or health outcomes, that might be served by remote-sensing data. Among them were myocardial infarction, arrhythmia, heart failure, hypertension, and stroke, in addition to a number of subclinical outcomes such as blood pressure changes and heart rate variability. Population-level application areas were also identified; they included hospital admissions and emergency room visits. Participants concluded that resolution limits might not pose problems for chronic applications, but that acute events like myocardial infarction and stroke would be better served by higher-resolution technology.

The developmental biology working group, moderated by Beate Ritz, an associate professor of epidemiology at the University of California, Los Angeles, identified several uses of remote-sensing data to assess developmental outcomes; they included critical windows of vulnerability that occur before, during, and following parturition; acute versus chronic pollutant exposure dynamics; and the interaction of maternal and fetal genetic susceptibilities. Participants also identified data needs such as adequate temporal and spatial resolution in pollution measures, and improved identification and quantification of chemical species in air pollution.

The workshop prompted Earth and health scientists to begin a dialogue to develop web-based pilot studies that integrate existing remote-sensing data with ground-based analyses as a preliminary step toward this broader validation. The workshop generated significant enthusiasm for collaboration between NIEHS extramural researchers and scientists at the participating agencies and for the possible use of remote-sensing air quality and climate data to improve public health. Ideally, space-based measures will produce new views of air pollution and the extent of human exposure, possibly leading to better opportunities to protect public health.

–Charles W. Schmidt

A virtual journey to real health. The Veggie-Mon website uses a cartoon character (inset) to introduce students to concepts of good diet, nutrition, and healthy lifestyle choices. In one activity, students take a virtual journey along Tobacco Road and read billboards with messages about smoking.

Veggie-mon.org

BEYOND THE BENCH

Online and On Track with Veggie-Mon

Too much computer time may not be good for kids, but sometimes surfing the Internet can be a wholesome activity, especially when it involves websites that help children learn how to make informed choices about their own health. One such site is the Veggie-Mon website at http://www.veggie-mon.org/. Created in 2000 by the Community Outreach and Education Program (COEP) of The Center for Research on Environmental Disease, a joint NIEHS center of The University of Texas M.D. Anderson Cancer Center and The University of Texas at Austin, the Veggie-Mon website has informed thousands of kids about the choices they can make to lead a healthy life.

The Veggie-Mon site introduces concepts of environmental risk factors and disease prevention to elementary- and middle-school students in a compelling and comprehensible way. "The goal of the site is to inform students, even young ones, that they can have an important and long-term impact on their own health by reducing their exposure to environmental risk factors and improving their diet," says COEP director Robin Fuchs-Young.

The homepage offers three portals, one for students in grades 4–6, one for students in grades 7–8, and one for teachers. Both student portals present information on three main topics: nutrition, sun and ultraviolet (UV) exposure, and tobacco use. According to Fuchs-Young, these are among the most important environmental risks faced by school-age children, and are also some of the risks that are most easily mitigated.

Each visitor is accompanied through the different sections by Veggie-Mon himself, a character reminiscent of a walking, talking artichoke who offers site navigation tips and provides extra details on the information presented. Each of the three sections has information that is both informative and fun. Along the way, Veggie-Mon encounters different acquaintances who help him explain the subject matter.

In the Nutrition section, students meet Strawberry Girl, an advocate of healthy eating habits. Here students can learn how to make healthy food choices through an illustrated food pyramid, and can also find recipes for delicious, wholesome snacks like a strawberry banana blast or a peanut butter and honey sandwich.

The Sun and UV section features Sunspot, a character who discusses some of the dangers of too much sunlight. In this section, students learn how fish research is helping scientists study the connection between sun exposure and skin cancer, and they can also take Sunspot's quiz to gauge how much they've learned.

In the Tobacco Road section, students meet Igna-Ray-Mouse, a misinformed rodent who has decided to smoke. Here they can take a virtual journey down Tobacco Road with Igna-Ray-Mouse and learn how advertising messages and peer pressure may be used to try to convince them to smoke. At each fork in the road, evidence is presented to prove that choosing to smoke is a bad idea.

Other tools on the site include a submission form to send questions to real scientists, a glossary, and a "laboratory" with instructions for simple experiments that students can conduct themselves. Each section also includes age-appropriate games and puzzles.

Teachers have their own features on the site. In a password-protected area, they can access lesson plans and provide feedback on how the website has helped them with classroom activities. Educators also contribute directly to the development of the website. During a 4- to 6-week educator fellowship held each summer at The Center for Research on Environmental Disease, teachers from grades K–12 help the COEP staff translate center research findings into age-appropriate content.

The COEP regularly revises the Veggie-Mon website to improve its usefulness for both students and teachers. Next up for the site is an exercise unit for the Nutrition section that will offer suggestions for fun and safe activities as well as information on healthy weight maintenance. **–Tanya Tillett**

Headliners | Uterine Leiomyoma

NIEHS-Supported Research

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Genetic Reprogramming and Benign Uterine Tumors

Cook JD, Davis BJ, Cai SL, Barrett JC, Conti CJ, Walker CL. 2005. Interaction between genetic susceptibility and early-life environmental exposure determines tumor-suppressor-gene penetrance. Proc Natl Acad Sci USA 102:8644–8649.

Uterine leiomyomas (fibroids) are common benign tumors in the muscle tissue of the uterus. Previous research has suggested a link between environmental exposures and uterine fibroids. NIEHS grantee Cheryl Lyn Walker and colleagues at The University of Texas M.D. Anderson Cancer Center were interested in how such exposures contribute to uterine fibroids. They propose that early-life exposure to xenoestrogens may alter genetic programming during development, setting the stage for an adverse response to later natural estrogen stimulation.

Uterine fibroids occur in up to 77% of women, can cause severe menstrual bleeding and pelvic discomfort, and result in more than 200,000 hysterectomies each year in the United States alone; although "benign," they are far from harmless. Lesions causing symptoms range in size from 1 to 20 centimeters. Data indicate that 25% of white women have problematic lesions. Black women have about a threefold higher risk of developing fibroids and, in general, their clinical symptoms are worse.

Diethylstilbestrol (DES), a xenoestrogen, is one environmental exposure that has been posited as contributing to uterine fibroids. To determine the actions of this chemical, Walker and colleagues studied rats with a genetic predisposition to developing uterine fibroids, exposing some of them to DES during their first week of life. By age 16 months, the DES-exposed animals had almost a 95% incidence of tumor formation, while the unexposed animals had a 64% incidence. There were more tumors in each affected DES-exposed animal, and the tumors were larger in size and more invasive, compared to controls.

The researchers determined that DES did not cause a mutation in estrogen-responsive genes, but rather caused them to become "reprogrammed" so that they responded differently to natural estrogen stimulation later in life. These findings indicate that reprogramming of genes during the developmental period as a consequence of xenoestrogenic exposure can interact with a preexisting genetic condition to increase the formation and severity of uterine fibroids. If additional research confirms these results, this study's findings could have implications for other hormonally mediated cancers such as those of the breast and prostate. **–Jerry Phelps**