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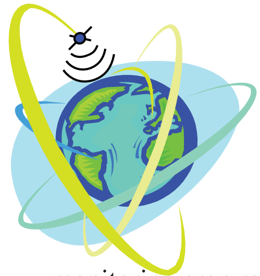

Understanding Earth From Space

When most people think of space satellites, they most likely don't think of agriculture. But the U.S. Department of Agriculture (USDA) is the largest U.S. civilian operational user of satellite imagery.

USDA's Agricultural Research Service (ARS) scientists are among the most prolific users of data from satellites launched by the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), foreign governments, and private industries around the world. Our research is behind some of the sensors on these satellites—satellites that are not aimed upward at our solar system and beyond, but rather downward at Earth's soil, plants, water, and atmosphere.

It was only 13 years after NASA's founding in 1959 that agriculture found its role in space, with sensors aboard NASA's first Landsat satellite. During 1999, NASA launched the seventh in a series of Landsat satellites, but an operational failure in 2003 has reduced its imaging capabilities. The Landsat Data Continuity Mission (Landsat 8) is not due to launch until 2012.

We are still getting valuable remote-sensing data from sensors aboard two NASA satellites, Aqua and Terra—both launched within the past decade—as well as NOAA weather satellites.

For hyperspectral imagery (systems with as many as several hundred spectral bands), the USDA currently relies on India's RESOURCESAT 1 satellite. Hyperspectral sensors let researchers choose from 256 wavelength bands to find the right ones for a particular task.

One of our latest successes is with hyperspectral imaging of the type used by Ray Hunt and Craig Daughtry from our Hydrology and Remote Sensing Laboratory in Beltsville, Maryland. (See stories on pages 4 and 5.) Hunt is working to transfer invasive-weed sensing-and-prediction technology to USDA's Forest Service, while Daughtry and others are working on crop residue-sensing technology for USDA's Natural Resources Conservation Service. The high-resolution hyperspectral sensor aboard SAT 1 is giving us detailed information on a timely basis.

NASA's Earth Observing-1 (EO-1) satellite has a high-resolution hyperspectral sensor named "Hyperion," but EO-1 is experimental, not operational, and it is beyond its expected lifetime, so we're lucky if it provides one useful image a day of a narrow swath of the planet. That's far from the broad coverage needed so that Earth is completely imaged at least every 5 days, which would increase the chances of getting a cloud-free view of the planet.

Unfortunately, for some applications, agricultural researchers need their imagery at the worst time of the year, early spring, when wet soils contribute to cloudy conditions that obscure Earth's surface. At that time of year, cloud cover interferes with imagery from one-half to two-thirds of the time.

NASA is considering the development of a new hyperspectral infrared imager satellite, known as "HyspIRI." In addition to monitoring crop residue and invasive plants with hyperspectral data, it would include high-resolution thermal imagery for monitoring plant evapotranspiration and drought on a 5-day cycle.

Other researchers at Beltsville have so far relied on airplane-mounted and infrequent satellite-based high-resolution thermal sensors—combined with coarse-resolution NOAA satellite imagery—to develop techniques for mapping evapotranspiration and drought at the field scale. This has attracted interest from the University of Nebraska, which publishes a national drought map online, in collaboration with NOAA. The World Bank is also interested in using these remote-sensing-based products for drought and water-use monitoring in the Middle East.

Mapping plant evapotranspiration and soil moisture via satellite has broad applications, such as monitoring water consumption, administering irrigation projects, and providing information for hydrologic and weather-forecast computer models.

Scientists from our labs are among the principal scientists serving on the science team for a new NASA satellite called SMAP (Soil Moisture Active-Passive) that was recommended as a top priority by the National Research Council. NASA recently set a December 2012 launch date for the mission to map Earth's water cycle.

ARS works with space agencies and private companies to optimize sensors for agricultural interests. Daughtry and a postdoctoral scientist are working on selecting the best infrared light wavelengths for detecting crop residue and weeds, as well as fertilizer deficiencies and crop damage, in the hope of enhancing the next sensors on India's RESOURCESAT 2, scheduled for launch during 2009. Daughtry's research might also influence sensor specifications for future satellites launched by the United States, China, France, Japan, and the United Kingdom.

Daughtry develops the mathematical equations for interpreting spectral data from sensors. His residue work is important because residue serves so many purposes critical to our nation—from protecting soil and sequestering carbon to biofuel production.

Detecting crop residue or invasive plants is part of the land-cover classification function that is a foundation for all remote-sensing work: You have to be able to distinguish vegetation from bare ground and assess plant and soil conditions to provide a context for all other remote-sensing applications for agriculture.

We have at least one scientist at locations in 33 states working on remote sensing. A growing number of ARS labs around the country are realizing that as remote-sensing science matures, agricultural research benefits from the use of remote-sensing data.

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