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Studying from a Distance

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In the not too distant future, farmers can decide when to plant, irrigate, and fertilize their crops using information from remote sensing.

Remote sensing is the process of observing and collecting data without physical contact between a sensor and an object. The human eye is perhaps the best example of a remote sensor, but today the term remote sensing is most often used to describe methods of gathering data by moving away from the earth.

Aerial remote sensing began in the 1800s when the first aerial photograph was snapped by a balloon-borne camera. And photographing enemy troop movements during World War I was one of the first extensive uses of the airplane. Remote sensing has now joined the space age with sensors sending information via satellites to computers for processing.

With remote sensing technology, scientists use information collected miles above the earth to better understand changes in natural resource characteristics. These characteristics are often difficult or impossible to detect with earthbound methods of research.

Remote sensing is used for a wide array of scientific endeavors including natural resources research. Scientists map coastal wetlands, identify particular types of vegetated areas, determine insect infestation in forests, detect changes in wildlife habitats, map areas of high mineralization, and monitor many other natural resource occurrences.

Remote sensing applications range all the way from hand-held cameras or field monitors installed on platforms to sophisticated scanning and communications equipment on satellites. The images generated from scanning sensors on satellites are not always as clear and detailed as those taken from airplanes or sensors closer to the study subject.

Satellites, however, offer many advantages for remote sensing because they cover broad areas of the earth repeatedly for a period of years.

Scanning sensors collect data in a long series which is digitized and transmitted to a computer. Scientists predict that the use of scanning sensors will increase in the future because they produce more objective results which are easily interpreted. Extracting data from a photograph is tedious and subject to interpretation. Often the results vary with the skills of the interpreter. In contrast, data from scanning sensors can be stored and recalled for comparison. This data from scanning sensors is stored by number with each number representing the intensity of radiation emitted or reflected from the sensed object.

Sensors can be either active or passive. Active sensors emit a signal which is reflected by the object; passive sensors detect levels of electromagnetic radiation reflected or emitted by an object or the earth's surface. Regardless of whether active or passive, most sensors produce a photographic image. Infrared color film, which depicts vegetation in various shades of red, is commonly used because it indicates subtle differences in vegetation.

Information from scanning sensors on satellites is particularly useful for monitoring change in environments such as coastal wetlands, wildlife habitats, or crop production areas. Researchers can, for example, map irrigated acreage quickly and accurately through remote sensing techniques. They can easiIy distinguish irrigated fields from non-irrigated and fallow fields by analyzing data generated from scanning sensors mounted on satellites.

With present remote sensing technology, scientists can also determine if a field has more moisture than another field, but they cannot tell how wet it is. Mapping irrigated acreage is still only a qualitative measurement since the information generated indictes either the pressence or absence of soil moisture.

Quantitative measurements which indicate the amount of a particular variable such as soil moisture are more difficult to obtain with present remote sensing techniques. Measurements to determine the amount of soil moisture in a particular field, however, would be extrmemly valuable to farmers for managment decisions on irrigation scheduling or planting dates.

Present efforts to determine area soil moisture involve installing an monitoring soil sensors in fields. An example is a monitoring program conducted by the High Plains Underground Water Conservation District in Lubbock and the Soil Conservation Service. The agencies have installed monitoring equipment in fields throughout the High Plains to record soil moisture levels. Since the equipment must be read in the field, data collection is time-consuming and expensive.

Soil and crop scientists at Texas A&M University (TAMU) are working on methods to use remote sensing techniques rather than field collection to determine soil moisture measurements.

"The problem has always been that the part of the soil which controls the data is very shallow," explains Cornelius van Bavel, a soil and crop scientist with the Texas Agricultural Experiment Station on the TAMU campus. "Active radar can only sense soil moisture one-half inch deep, so only the moisture of the earth's crust is measured. Passive sensing techniques are a little better. They will measure to a depth of one to two inches, but that's still not very much."

Farmers need to know the moisture content throughout the root zone--not just the top inch or two, says Van Bavel. Root zone depth varies with individual crops, but most field crops send roots at least two feet deep into the soil profile.

A model developed by Van Bavel and other scientists at TAMU will help make soil moisture monitoring by remote sensing closer to reality. It combines the information obtained through microwave remote sensing (the moisture in the top two inches of soil) with moisture distribution patterns for particular types of soil. The model also considers moisture loss by evaporation and moisture gained from precipitation.

"We have some partial verification of our data, but there's much work yet to be done," says Van Bavel. In this research, ground stations must continuously monitor soil conditions to see if soil moisture values predicted by the model match those found in the soil. This approach is known as "ground truth development" to compare the findings of actual measurements to those generated by remote sensing. Van Bavel estimates that it will take at least three to five years to fully evaluate the technology.

Although progress is incremental and its pace often frustrating to scientists, the adoption of remote sensing techniques in many areas is probably only a matter of time. Significant steps have already been taken to monitor environmental change with remote sensing techniques in other applications. Several studies such as monitoring the growth of noxious weeds in aquatic environments and determining the effect of upstream water impoundment on coastal wetlands have proved quite successful.

Scientists can also use remote sensing technology "up close" to study without touching or in any way disturbing a natural occurrence. James Heilman, a researcher in the Texas A&M University Department of Soil and Crop Sciences, has a project under way to assess the use of remote sensing to monitor field fertility needs. His study involves holding a remote sensing device called a radiometer over test plots of rice to measure radiation from the plots.

Heilman uses the measurements to assess the leaf area of the plot. Heilman explains that other methods of measuring leaf area involvetaking samples from the study area, whereas his remote sensing method does not disturb the crop in any way. Leaf area is used by scientists to evaluate the development stage and condition of a crop.

As Van Bavel, Heilman, and other scientists develop a data base to work from and build on, future remote sensing techniques will be valuable tools for agricultural producers and other natural resources

Uses of Remote Sensing by State Agencies in Texas, 1973-83	
Agencies	**Uses**
Air Control Board	To monitor carbon dioxide, nitrogen dioxide and sulfur dioxide and to measure smokestack plumes
Bureau of Economic Geology	To map land cover, geology, terrain, wetlands, and mineralization To photograph To photograph
Coastal and Marine Council	To photograph
Department of Agriculture	To photograph
Department of Health	To monitor solid waste landfills
Department of Water Resources	To inventory standing water behind dams (both surface acreage and water quality), estuary water quality, land use, and irrigation
Forest Service	To inventory clear cutting, land use, and forest stress from insects
General Land Office	To monitor surface mining
Highways and Public Transportation	To plan and design highways and to map
Parks and Wildlife	To monitor park facilities, map plant distribution, and inventory coastal resources
Railroad Commission	To monitor surface mining
Soil and Water Conservation Board	To map soils

Information from Bureau of Economic Geology