Revista Internacional de Ciencia y Tecnología de la Información Geográfica
International Review of Geographical Information Science and Technology

*Goward, S. N.(2007): "Land remote sensing in the 21st Century. Geotechnologies in service to human societies", GeoFocus (Editorial), nº 7, p.1-4, ISSN: 1578-5157*

# LAND REMOTE SENSING IN THE 21ST CENTURY. GEOTECHNOLOGIES IN SERVICE TO HUMAN SOCIETIES

SAMUEL N. GOWARD
Department of Geography
University of Maryland
College Park, MD, USA
sgoward@umd.edu

We began satellite monitoring of the Earth's land areas nearly a half century ago, in 1972, when the United States launched ERTS-1 (Earth Resources Technology Satellite 1, cum Landsat-1). Today the nations of the world have 10-20 such land observatories in orbit at any given time. With all this wealth of land observations it is increasingly difficult to understand why these remotely sensed data are not a more pervasive element of data systems that help inform human societies about the state and dynamics of our home planet. There are, no doubt, many possible explanations for the slow adoption of technology, including the simple conservative nature of senior managers to adopt new technologies. In this commentary, I will explore 4 additional possible reasons why adoption of this remote sensing technology has been so slow, including: 1) acquisition strategies, 2) data quality, 3) data access, and 4) operational commitment.

It is interesting to note that when the U.S. visionaries, including Pecora and Nordberg, first began to consider satellite land observatories, their vision was of a system that would routinely and repetitively monitor the Earth's land areas (Pecora, 1966). Unfortunately this global vision has not been shared by the developers of many other Landsat-type satellite imaging systems. The alternate, competing satellite land observation system model, is the "image-on-demand" model originally invoked by aerial photography and taken to the edge of space with the U-2 and SR-71 aircraft platforms during the US – USSR Cold War era. Most satellite land observatories, including SPOT, IRS and Landsat (during the 1984 -1992 commercial era) have been operated in the "on-demand" operations model. This results in, with the exception of Landsat (most of the time), our having little systematic, global archival coverage with which to evaluate how land patterns and processes look today compared to previous years. Imagery has much more value within context than as a single snapshot of current land cover state.

Recibido: 6/ 6/ 2007
Aceptada versión definitiva: 8 / 6/ 2007

*Goward, S. N.(2007):* **"***Land remote sensing in the 21st Century. Geotechnologies in service to human societies", GeoFocus (Editorial), nº 7, p.1-3, ISSN: 1578-5157*

A second problem that has plagued applications of land remote sensing is how the data are generally made available to users. Early Landsat observations were predominately supplied to users as digitally-produced photo products. The data preprocessing that was applied to this imagery was minimal because of the limited computer processing power available in the late 1970s (mainframes and mini-computers). This "Level 1" systematically-adjusted (for engineering issues only) became the default remote sensing data standard as we transitioned to computer-based image processing analysis and incorporation into geographic information systems (GIS) (Bernstein, 1983). Unfortunately there is much processing of the data still needed before it is imagery-ready-to-use (IRU). At the least, IRUs should be ortho-rectified to a specific map base and radiometrically processed (i.e. calibrated and atmospherically adjusted) to surface spectral reflectance patterns. Other factors that perhaps should be addressed include image compositing to remove clouds and cloud shadows, as well as adjustments for bi-directional reflectance effects. Much of this is easily achieved today with readily available computer processing systems (Masek, Wolfe et al., 2007). We need to move remote sensing data from Level 1 to IRU.

The third constraint on effective use of land remote sensing data is access to the data itself. We have suffered through many years of nations attempting to recover the cost of land satellite observatories through privatization or commercialization. Individual images have been priced in the $1000 to $5000 range. If a state or a nation agency wished to acquire annual observations of its total areal extent, the costs typically would be in the millions of dollars, unless of course you are interested in a very small area like the State of Rhode Island in the US. This cost must be incurred before anything can be learned from the imagery and before it is even ready to be placed in a regional geographic information system (GIS) that includes other mapped information. Cost, however, is not the only factor. What data are available, and for what time periods, is typically very painful for a user to discover. As an example, we recently completed an analysis of the Landsat observations that exist in the U.S. National Satellite Land Remote Sensing Data Archive (NSLRSDA) in the USGS EROS facility in Sioux Falls, South Dakota (Goward, Arvidson *et al*., 2006). In short, we discovered that the U.S holds about 2 million Landsat scenes for the globe, spanning the time period from the 1972 - 2005. In addition, there are several Landsat International Cooperators (I.C.) which have archived well over 4 million Landsat scenes, most of which does not reside in the US archive. At the moment we do not know what particular scenes are held in each I.C. archive or whether they are still preserved or available. Currently there is considerable effort to rectify this situation, but only for Landsat. What about the other imagery archives for the other satellite systems? How do we merge all this metadata, so that a user can find out what data are accessible for their particular interest?

Probably the most serious of the limitations with regard to the applied use of satellite remote sensing data is the day-to-day uncertainty about continued access to satellite observations. As strange as it may seem, although the Landsat system has been in existence for more than 35 years now, it has always been described as "experimental". The incessant politics associated with commercialization and/or national operational commitments have plagued the land observatories from their very foundations in the 1960's (National Research Council, 1969). Most potential operational users are highly resistant to adoption of experimental technologies, which may or may not be around tomorrow, to support their continued operational requirements. Only recently have

*Goward, S. N.(2007): "Land remote sensing in the 21st Century. Geotechnologies in service to human societies", GeoFocus (Editorial), nº 7, p.1-3, ISSN: 1578-5157*

many of the nations that have flown Landsat-class observatories come to recognize that these observatories are complements to weather satellites and of critical importance to monitoring the state and dynamics of the land areas of the planet. We have yet to see the nations of the world stepping up to the long-term national operational commitment to land observations that would make this a reality, although most nations have the international commitment to do so through GEOSS (Global Earth Observation System of Systems) http://www.earthobservations.org/index.html and IGOL (Integrated Global Observations for Land) http://www.fao.org/gtos/igol/. The U.S. today is struggling with this problem through a high level Future of Land Imaging committee, intended to lead to a National Land Imaging Program http://www.landimaging.gov/. Moving to national operational commitments to Landsat-class observatories is the first step in creating international consortia that coincidentally operate several satellites, such as LDCM (Landsat Data Continuity Mission), Sentinel 2 (European), CBERS (China-Brazil Earth Resources Satellite, IRS (India Remote Sensing satellite) and others, to provide a global observatory system that systematically monitors the Earth's land areas a primary source of global change.

The time has come for nations, politicians, scientists, engineers and citizens of the world to make the transition from experimental land remote sensing to operational monitoring. Such a move will force rapid advances in all the other issues noted in this commentary. Getting beyond limited global coverage, hard-to-access data, which must be heavily pre-processed before it is ready to use in high-quality geospatial information systems will be the first step in national and international efforts to come to grip with emerging trends in global change.

**References Cited**

Bernstein, R. (1983): "Image geometry and rectification", In *Manual of Remote Sensing* (ed R.N. Colwell), pp. 873-922. American Society of Photogrammetry, Falls Church, Virginia.

Goward, S.N., Arvidson, T.J., Williams, D.L., Faundeen, J., Irons, J., & Franks, S. (2006): "Historical record of Landsat global coverage: Mission Operations, NSLRSDA, and international cooperator stations", *Photogrammetric Engineering and Remote Sensing*, *70*(10), 1155-1170.

Masek, J.G., Wolfe, R., Hall, F., Goward, S.N., Huang, C., Cohen, W., R., K., Powell, S., Healey, S., & Moisen, G. (2007): "Assessing North American Forest Disturbance from the Landsat Archive". In *IGARRS 2007*. IEEE, Spain.

National Research Council (1969). *Useful Applications of Earth-Oriented Satellites*. National Academy of Sciences, Washington, D.C.

Pecora, W.T. (1966). *Earth Resources Observation Satellite (EROS): A Department of Interior program to utilize space-acquired data for natural and human resource management*. U.S. Dept Interior, US Geological Survey, Washington D.C.