# Remote Sensing and Environment

**Tarannum Vahid Attar[1], Kamala Balasubramanian[2]**

*[1,2]Deprtment of Physics, K.M.E Society's G.M.Momin Womens College, Rais High School Campus, Thana Road, Bhiwandi 421302, Maharashtra*

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***Abstract: From its origins, the Earth has experienced change as a natural process over time scales ranging from years to thousands of years and more. There are strong scientific indications that natural change is being accelerated by human intervention, resulting in rapid land cover conversions, reductions in biodiversity and habitat, degraded water quality and changes in the composition of the atmosphere, including climate warming. Neither the short-term effects of human activities nor their long-term implications are fully understood. However, if climate and human interventions with the environment are to be understood, more effective and advanced environmental research and monitoring tools need to be developed and implemented. Remote sensing from space-based platforms is one such powerful tool for environmental monitoring of the Earth's surface and atmosphere. Satellite sensor systems, with their synoptic and repetitive coverage of the land surface, are increasingly being relied on to characterize and map the spatial variation of relevant surface properties for environmental applications. Remote sensing may be the only feasible means of providing such spatially distributed data at multiple scales, and on a consistent and timely basis. Remote sensing systems often employ sensors that record discrete segments of electro- magnetic energy. Inherent in the analysis of remotely sensed data is the use of computer-based image processing techniques, which enhance the interpretability of remotely sensed data.***

***Keywords: remote sensing, environment, sensors, landsat satellite***

## 1. INTRODUCTION

Over the past decade, renewed and expanding interest in practical applications of Earth observations from space and airborne platforms has coincided with and been fueled by changes in the data, in how they can be used, and in who produces them. There have been significant improvements in the availability of remote sensing data and in their spectra and spatial resolution. In addition, the data can be adapted for more varied uses because of the extension and advancement of complementary spatial data technology such as Geographic Information Systems (GIS) and the Global Positioning Systems (GPS) which can be used in conjunction with remote sensing data. During the same period, the institutional support for producing remote sensing data has also become more diversified.

**The need for measurement**: Whether it be for meteorological, hydrological, occeangraphic or climatological studies or for any other activity relating to the natural environment measurements are vital. A knowledge of what has happened in the past and of the present situation and an understanding of the processes involved can only be arrived at if measurements are made. Such knowledge is also a prerequisite of any attempt to predict what might happen in the future and subsequently to check whether the predictions are correct. Without data, none of these activities is possible. Measurements are the cornerstone of them all.

**Physical principle of Remote Sensing:** Remote Sensing refers to the acquisition of biophysical and geochemical information about the condition and state of the land surface by sensors that are not in direct physical contact with it. This information is transmitted in the form of electromagnetic radiation (EMR). Broadly, there are two types of sensing systems to record the information about the earth's surface and atmosphere. They are active sensing system and passive sensing system. An active sensing system generates and uses its own energy to illuminate the target and records the reflected energy which carries the information content or entropy. Synthetic aperture radar (SAR) is one of the best examples of active sensing systems. These sensing systems operate in the microwave region of electromagnetic spectrum and include radiation with wavelength longer than 1mm. The second type of remote sensing systems are passive systems mainly depending on the solar radiation operates in visible and infrared region of electromagnetic spectrum. The nature and properties of the target materials can be inferred from incident electromagnetic energy that is reflected, scattered or emitted by these materials on the earth's surface and recorded by the passive sensor (for example, a camera without flash). A fundamental principle underlying the use of remotely sensed data is that different objects on the earth's surface and in the atmosphere reflect, absorb, transmit or emit electromagnetic energy (EME) in different proportions across the range of wavelengths known as the electromagnetic spectrum and that such differences allow these objects to be identified uniquely. Sensors mounted on aircraft or satellite platforms record the magnitude of the energy flux reflected from or emitted by objects on the Earth's surface. These measurements are made at a large number of points distributed either along a one dimensional profile on the ground below the platform or over a two-dimensional area below or to one side of the ground track of the platform. The relationship between the "source" signal or irradiance interacting with the surface and the reflected "received" signal at the sensor provides the information that is used in remote sensing to characterize the Earth's surface. The remotely sensed signal is composed of energy representing different wavelengths over the electromagnetic spectrum.

The most important regions of the electromagnetic spectrum for environmental remote sensing are listed in Table1 in order of increasing wavelength.

**Table1: Regions of the Electromagnetic spectrum used in Environment monitoring**

| Spectral Region | Wavelength | Application |
|---|---|---|
| Ultraviolet(UV) | 0.003 to 0.4 [μm] | Air pollutants |
| Visible(VIS) | 0.4 to 0.7 [μm] | Pigments, Chlorophyll, iron |
| Near infrared (NIR) | 0.7 to 1.3 [μm] | Canopy structure, biomass |
| Middle infrared | 1.3 to 3.0 [μm] | Leaf moisture, wood, litter |
| Thermal infrared(TIR) | 3 to 14 [μm] | Drought, plant stress |
| Microwave | 0.3 to 300 [cm] | Soil moisture, roughness |

The ultraviolet portion of the spectrum is useful in atmosphere pollution studies including ozone depletion monitoring. The visible portion of the spectrum is how human beings "see" reflected energy patterns of the earth and is useful in vegetation, soil, ice and ocean monitoring with the use of pigment and mineralogical properties of surface material. The near infrared region is useful in assessing the quantity of biomass at the surface of the earth, whereas the middle-infrared region is most sensitive to leaf moisture contents in vegetation. The ultraviolet, visible, near-infrared and middle-infrared regions are combinely referred as shortwave radiation. The thermal infrared region, also known as longwave radiation, is useful in assessing the temperature of the Earth's surface and has been used in vegetation stress detection and thermal pollution studies. The microwave region is cloud transparent and has been used to map vegetation and measure soil moisture.

There have been important atmosphere influences that alter the solar irradiance reaching the earth's surface, as well as the reflected energy reaching a spaceborne or airborne sensor. There are also gases in the atmosphere that trap and absorb the solar radiation, including water vapor ($H_2O$), Carbon dioxide ($CO_2$), Ozone ($O_3$), nitrous oxide ($N_2O$), methane($CH_4$) and oxygen($O_2$). These gases reduce the overall transmissive properties of the atmosphere and interfere with the measurement and monitoring of the land surface. Thus, for the potential of satellite data for land-monitoring applications to be fully realized, data are typically "corrected" for atmospheric interference of background.

**Remote Sensing at the landscape scale**: There is a wide array of airborne and satellite sensor systems currently available for environmental studies of the land surface. These are able to measure the reflected and emitted (thermal) energy from the land surface over a wide range of spatial and temporal scales and over various wave bands and sun-view geometries. At the landscape level, it is much more difficult to interpret the remote sensing signal because of land surface heterogeneity and the presence of "mixed" pixels, in which soil, plant, litter, and water may be present within the same pixel. Resolving the extent and spatial heterogeneity of these surface components are important for assessments of landscape, hydrological and biogeochemical processes.

**Sensor characteristics:** The discrimination of surface features is not only a function of the bio-geochemical and optical-geometric properties of the surface, but also sensor characteristics such as the number of and location of wavebands, spatial resolution and instrument calibration. Spaceborne sensors may be characterized in terms of their spatial, spectral, temporal and radiometric resolutions, with finer resolutions generally enhancing the detection and monitoring of Earth surface features.

Most of the satellite sensor systems used in environment remote sensing are “polar orbiting”. These are generally at low orbits (600-950km above the surface) and have pixel sizes in the range of 1[m] to 1[km], with successive orbits close to the poles and constant equatorial crossing times. For environment applications, two types of polar orbiting sensor systems can be differentiated: the fine resolution sensor with small pixel sizes (< 100m) but low repeat frequencies (>16 days) and moderate resolution sensors with coarser pixel sizes (250m to 1km) and higher repeat frequencies (1-2 days). The moderate resolution sensors are useful in seasonal and time series applications at regional to global scales, whereas the fine resolution studies are more useful in local environment applications.

**Fine Resolution Sensors:** The Landsat series of satellites has been the most widely used in remote sensing of the environment. Landsat satellite orbits the Earth in a near-polar, sun-synchronous pattern at a nominal altitude of 705[km] and 16 days repeat cycle. The land sat programme began in 1972 with the Multispectral scanner (MSS) sensor consisting of four broad bands in the visible and NIR regions, with a pixel size of 80[m] and a repeat cycle of 18 days. The fourth and fifth Landsat satellites launched in 1982 and 1984 respectively included the Thematic Mapper (TM) sensor, in addition to the MSS sensor. The TM sensor has seven spectral bands, including two in the MIR region and one in the thermal region, and a pixel size of 30[m], which allowed for greatly increased multispectral characterization of the land surface. Landsat TM bands 5(1.55-1.75 μm) and 7(2.08-2.35 μm) are within the water sensitive region and offer potential soil indicators. The Enhanced Thematic Mapper(ETMT), launched in April 1999, further improved Landsat capabilities with an improved 15[m] panchromatic band and a 60[m] thermal band.

The landsat satellites have imaged the Earth for nearly three decades, enabling environmental and global change researchers the opportunity to quantitatively assess land use patterns and land cover changes. Land cover is subject to change through natural cycles (droughts, fires, succession, floods, volcanic activity) and human land use activities such as agriculture, forestry, grazing and urbanization with a doubling of the human population over the past half-century, landscapes are subject to increasing levels of stress, which often lead to land degradation with accelerated soil erosion, loss of biodiversity and water quality, and increasing human health risks. Land cover conversion is often directly observable with remote sensing, such as when forest is converted to pasture in the case of deforestration. As much as 60% of the global terrestrial surface demonstrates some degree of large scale conversion, and an important goal of satellite sensor systems is to determine the rate at which anthropogenic land surface alteration is occurring within the global environment.

**Opportunities in Satellite Remote Sensing**: Advances in remote sensing systems, data communications and processing technologies and numerical models-including data assimilation techniques present a rich set of “push” opportunities for realizing the vision of the Earth Information System and associated enhanced weather and climate observations and predictions.

A variety of advanced and complementary instruments on a constellation of satellites in different orbits (eg. Geostationary, polar and inclined low Earth, highly elliptical and Sun-Stationary) combined with ground base balloons and aircraft in situ and remote sensing systems, will eventually form an intelligent sensor web. The data from this web can be continuously assimilated into high resolution numerical models of the atmosphere. The observation and analysis process will yield a quasi-continuous digital representation of Earth on a global basis. This global database, which will include a complete and accurate representation of the atmosphere and land and ice surfaces is needed in order to enable much more accurate weather forecasts, to characterize the climate and to advance understanding of the Earth System.

New space-based remote sensing, communication and processing technologies are being demonstrated through a number of research and development programs. The next-generation National Polar-orbiting operational Environmental Satellite System by NASA represents a giant step forward in global weather sensing capability. Imaging Fourier transform spectrometers providing hyperspectral imagery of the atmosphere with unprecedented resolution, are being developed observe the dynamics of the three dimensional thermodynamic structure of the troposphere with high spatial and temporal resolution from geostationary satellites. Scatterometers will provide surface wind data over the occeans. Lidars and radars will fly on low-altitude satellite for cloud aerosol, and precipitation measurements with the future possibility for high-vertical resolution water vapor profiling. The advanced instruments that detect the natural microwave radiation emitted by Earth’s surface and atmosphere will enable atmospheric profiling through clouds and will provide surface, wind and precipitation observations. Dual frequency radars will measure precipitation and associated latent heating rates. A visible wavelength digital camera, which will sense lightning strokes, is also being developed to monitor convective storm dynamics from geostationary satellites.

Remote Sensing images including the information extracted from such images, along with GPS data, have become primary data sources for modern GIS. Indeed, the boundaries between remote sensing, GIS and GPS technology have become blurred and these combined fields will continue to revolutionize the inventory, monitoring and managing natural resources on a day-to-day basis. Similarly these technologies are assisting us in modeling and understanding biophysical process at all scales.

**Conclusion:** Remote sensed imagery can provide both snapshots and data over time that addresses environmental issues at global, regional and national scales. It can provide these in consistent formats and in ways that complement national-level data collection efforts which are often under-resourced and inconsistent from country to country.

Remote Sensing is an unparalleled source of information that conveys environmental changes in a visually compelling way. As a result, it is extremely useful for raising awareness and developing the political support necessary to strengthen MEAs (multilateral environment agreements) and environmental laws at the national level.

## REFERENCES


*[1]* Colgan, C. S., and R.Weiher, *Linking Economic and Environmental Goals in NOAA's Strategic Planning, Draft NOAA report,* Washington 2003.

[2] Curran., P.J., *Principles of Remote sensing, ELBS 1*988; 282.

[3] Elachi C., *Introduction to physics and Techniques of Remote Sensing,* Wiley, New York 1987.

[4] Elison E. M., and McEwen, A.S., *Photogrammetric Engineering and Remote Sensing* 1990; 56: 453-458.

[5] Fungry., A. K., *Remote Sensing for Environmental Sciences,* Springs Verlag, Beden 1976.

[6] Goodchild., M.F. Parks., B.O, and Stayyaert., L.T.,*Environment Modelling with GIS.,* Oxford Univ. Press, Oxford and new York 1993.

[7] Henderson, S.T., *Daylight and its Spectrum,* Adam Hilger Ltd, London 1970; 363.

[8] Jenson, J.R. *Image Processing: An overview of Photogrammetric Engineering and Remote Sensing*1983; (49): 1151-7.

[9] Lillesand., T.M. and R.W.Keifer,*Remote Sensing and Image Interpretation,* John Wiley and sons, New York 2000.

[10] Mead., R.A and Szajgin., J., *Landsat classification Accuracy Assessment procedures, Photogrammetric Engineering and Remote Sensing* 1982;(4): 497-501.

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