Chapter 1 : Remote sensing - GIS Wiki | The GIS Encyclopedia

The history of Satellite remote sensing can be traced back to the early days of the space age of both Russian and American programs. It actually began as a dual approach of imaging surfaces, from spacecraft, using several types of sensors.

Play media This video is about how Landsat was used to identify areas of conservation in the Democratic Republic of the Congo , and how it was used to help map an area called MLW in the north. Passive sensors gather radiation that is emitted or reflected by the object or surrounding areas. Reflected sunlight is the most common source of radiation measured by passive sensors. Examples of passive remote sensors include film photography , infrared , charge-coupled devices , and radiometers. Active collection, on the other hand, emits energy in order to scan objects and areas whereupon a sensor then detects and measures the radiation that is reflected or backscattered from the target. RADAR and LiDAR are examples of active remote sensing where the time delay between emission and return is measured, establishing the location, speed and direction of an object. Illustration of remote sensing Remote sensing makes it possible to collect data of dangerous or inaccessible areas. Remote sensing applications include monitoring deforestation in areas such as the Amazon Basin , glacial features in Arctic and Antarctic regions, and depth sounding of coastal and ocean depths. Military collection during the Cold War made use of stand-off collection of data about dangerous border areas. Remote sensing also replaces costly and slow data collection on the ground, ensuring in the process that areas or objects are not disturbed. Other uses include different areas of the earth sciences such as natural resource management , agricultural fields such as land usage and conservation, [6] [7] and national security and overhead, ground-based and stand-off collection on border areas. For a summary of major remote sensing satellite systems see the overview table. Applications of remote sensing[edit] Further information: Remote sensing geology and Remote sensing archaeology Conventional radar is mostly associated with aerial traffic control, early warning, and certain large scale meteorological data. Other types of active collection includes plasmas in the ionosphere. Laser and radar altimeters on satellites have provided a wide range of data. By measuring the bulges of water caused by gravity, they map features on the seafloor to a resolution of a mile or so. By measuring the height and wavelength of ocean waves, the altimeters measure wind speeds and direction, and surface ocean currents and directions. Ultrasound acoustic and radar tide gauges measure sea level, tides and wave direction in coastal and offshore tide gauges. Light detection and ranging LIDAR is well known in examples of weapon ranging, laser illuminated homing of projectiles. LIDAR is used to detect and measure the concentration of various chemicals in the atmosphere, while airborne LIDAR can be used to measure heights of objects and features on the ground more accurately than with radar technology. Radiometers and photometers are the most common instrument in use, collecting reflected and emitted radiation in a wide range of frequencies. The most common are visible and infrared sensors, followed by microwave, gamma ray and rarely, ultraviolet. They may also be used to detect the emission spectra of various chemicals, providing data on chemical concentrations in the atmosphere. Spectropolarimetric Imaging has been reported to be useful for target tracking purposes by researchers at the U. They determined that manmade items possess polarimetric signatures that are not found in natural objects. These conclusions were drawn from the imaging of military trucks, like the Humvee , and trailers with their acousto-optic tunable filter dual hyperspectral and spectropolarimetric VNIR Spectropolarimetric Imager. These thematic mappers take images in multiple wavelengths of electro-magnetic radiation multi-spectral and are usually found on Earth observation satellites , including for example the Landsat program or the IKONOS satellite. Maps of land cover and land use from thematic mapping can be used to prospect for minerals, detect or monitor land usage, detect invasive vegetation, deforestation, and examine the health of indigenous plants and crops, including entire farming regions or forests. Weather satellites are used in meteorology and climatology. Hyperspectral imaging produces an image where each pixel has full spectral information with imaging narrow spectral bands over a contiguous spectral range. Hyperspectral imagers are used in various applications including mineralogy, biology, defence, and environmental measurements. Within the scope of the combat against desertification , remote sensing allows researchers to follow up and monitor risk areas in the long term, to determine desertification factors, to support decision-makers in defining relevant measures of environmental management, and to assess their impacts. Overhead gravity data collection was first used in aerial submarine detection. Seismograms taken at different locations can locate and measure earthquakes after they occur by comparing the relative intensity and precise timings. Ultrasound sensors, that emit high frequency pulses and listening for echoes, used for detecting water waves and water level, as in tide gauges or for towing tanks. To coordinate a series of large-scale observations, most sensing systems depend on the following: High-end instruments now often use positional information from satellite navigation systems. The rotation and orientation is often provided within a degree or two with electronic compasses. Compasses can measure not just azimuth i. More exact orientations require gyroscopic-aided orientation , periodically realigned by different methods including navigation from stars or known benchmarks. Inverse problem Generally speaking, remote sensing works on the principle of the inverse problem. While the object or phenomenon of interest the state may not be directly measured, there exists some other variable that can be detected and measured the observation which may be related to the object of interest through a calculation. The common analogy given to describe this is trying to determine the type of animal from its footprints. For example, while it is impossible to directly measure temperatures in the upper atmosphere, it is possible to measure the spectral emissions from a known chemical species such as carbon dioxide in that region. The frequency of the emissions may then be related via thermodynamics to the temperature in that region. The quality of remote sensing data consists of its spatial, spectral, radiometric and temporal resolutions. Spatial resolution The size of a pixel that is recorded in a raster image â€" typically pixels may correspond to square areas ranging in side length from 1 to 1, metres 3. Spectral resolution The wavelength of the different frequency bands recorded â€" usually, this is related to the number of frequency bands recorded by the platform. Current Landsat collection is that of seven bands, including several in the infrared spectrum, ranging from a spectral resolution of 0. The Hyperion sensor on Earth Observing-1 resolves bands from 0. Radiometric resolution The number of different intensities of radiation the sensor is able to distinguish. Typically, this ranges from 8 to 14 bits, corresponding to levels of the gray scale and up to 16, intensities or "shades" of colour, in each band. It also depends on the instrument noise. Temporal resolution The frequency of flyovers by the satellite or plane, and is only relevant in time-series studies or those requiring an averaged or mosaic image as in deforesting monitoring. Cloud cover over a given area or object makes it necessary to repeat the collection of said location. In order to create sensor-based maps, most remote sensing systems expect to extrapolate sensor data in relation to a reference point including distances between known points on the ground. This depends on the type of sensor used. For example, in conventional photographs, distances are accurate in the center of the image, with the distortion of measurements increasing the farther you get from the center. Another factor is that of the platen against which the film is pressed can cause severe errors when photographs are used to measure ground distances. The step in which this problem is resolved is called georeferencing , and involves computer-aided matching of points in the image typically 30 or more points per image which is extrapolated with the use of an established benchmark, "warping" the image to produce accurate spatial data. As of the early s, most satellite images are sold fully georeferenced. In addition, images may need to be radiometrically and atmospherically corrected. Radiometric correction Allows avoidance of radiometric errors and distortions. The illumination of objects on the Earth surface is uneven because of different properties of the relief. This factor is taken into account in the method of radiometric distortion correction. Topographic correction also called terrain correction In rugged mountains, as a result of terrain, the effective illumination of pixels varies considerably. In a remote sensing image, the pixel on the shady slope receives weak illumination and has a low radiance value, in contrast, the pixel on the sunny slope receives strong illumination and has a high radiance value. For the same object, the pixel radiance value on the shady slope will be different from that on the sunny slope. Additionally, different objects may have similar radiance values. These ambiguities seriously affected remote sensing image information extraction accuracy in mountainous areas. It became the main obstacle to further application of remote sensing images. The purpose of topographic correction is to eliminate this effect, recovering the true reflectivity or radiance of objects in horizontal conditions. It is the premise of quantitative remote sensing application. Atmospheric correction Elimination of atmospheric haze by rescaling each frequency band so that its minimum value usually realised in water bodies corresponds to a pixel value of 0. The digitizing of data also makes it possible to manipulate the data by changing gray-scale values. Interpretation is the critical process of making sense of the data. Image Analysis is the recently developed automated computer-aided application which is in increasing use. Object-Based Image Analysis OBIA is a sub-discipline of GIScience devoted to partitioning remote sensing RS imagery into meaningful image-objects, and assessing their characteristics through spatial, spectral and temporal scale. Old data from remote sensing is often valuable because it may provide the only long-term data for a large extent of geography. At the same time, the data is often complex to interpret, and bulky to store. Modern systems tend to store the data digitally, often with lossless compression. The difficulty with this approach is that the data is fragile, the format may be archaic, and the data may be easy to falsify. One of the best systems for archiving data series is as computer-generated machine-readable ultrafiche , usually in typefonts such as OCR-B , or as digitized half-tone images. Ultrafiches survive well in standard libraries, with lifetimes of several centuries. They can be created, copied, filed and retrieved by automated systems. They are about as compact as archival magnetic media, and yet can be read by human beings with minimal, standardized equipment. Data processing levels[edit] To facilitate the discussion of data processing in practice, several processing "levels" were first defined in by NASA as part of its Earth Observing System [17] and steadily adopted since then, both internally at NASA e. Level Description 0 Reconstructed, unprocessed instrument and payload data at full resolution, with any and all communications artifacts e. A Level 1 data record is the most fundamental i. Level 2 is the first level that is directly usable for most scientific applications; its value is much greater than the lower levels. Level 2 data sets tend to be less voluminous than Level 1 data because they have been reduced temporally, spatially, or spectrally. Level 3 data sets are generally smaller than lower level data sets and thus can be dealt with without incurring a great deal of data handling overhead. These data tend to be generally more useful for many applications. The regular spatial and temporal organization of Level 3 datasets makes it feasible to readily combine data from different sources. While these processing levels are particularly suitable for typical satellite data processing pipelines, other data level vocabularies have been defined and may be appropriate for more heterogeneous workflows. This section does not cite any sources. Please help improve this section by adding citations to reliable sources. 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Chapter 2 : Remote Sensing: History, Principles and Types

First, the term "remote sensing" was initially introduced in Before the term used was generally aerial photography. However, new methods and technologies for sensing of the Earth's surface were moving beyond the traditional black and white aerial photograph, requiring a new, more comprehensive term be established.

Reproduction is permitted for noncommercial purposes. This article has been cited by other articles in PMC. Abstract The history of remote sensing and development of different sensors for environmental and natural resources mapping and data acquisition is reviewed and reported. Application examples in urban studies, hydrological modeling such as land-cover and floodplain mapping, fractional vegetation cover and impervious surface area mapping, surface energy flux and micro-topography correlation studies is discussed. The review also discusses the use of remotely sensed-based rainfall and potential evapotranspiration for estimating crop water requirement satisfaction index and hence provides early warning information for growers. The review is not an exhaustive application of the remote sensing techniques rather a summary of some important applications in environmental studies and modeling. With the availability of remotely-sensed data from different sensors of various platforms with a wide range of spatiotemporal, radiometric and spectral resolutions has made remote sensing as, perhaps, the best source of data for large scale applications and study. In this review, we summarize some of the most commonly used applications of the technique in environmental resources mapping and modeling. Applications of remote sensing in hydrological modeling, watershed mapping, energy and water flux estimation, fractional vegetation cover, impervious surface area mapping, urban modeling and drought predictions based on soil water index derived from remotely-sensed data is reported. The review also summarizes the different eras of sensors development and remote sensing and future directions of the remote sensing applications. Evolution and advances in remote sensing satellites and sensors for the study of environments There are eight distinct eras of remote sensing; some running parallel in time periods, but are distinctly unique in terms of technology, concept of utilization of data, applications in science, and data characteristics e. These are discussed below: Airborne remote sensing era: The airborne remote sensing era evolved during the first and the Second World War Avery and Berlin, , Colwell, During this time remote sensing was mainly used for the purposes of surveying, reconnaissance, mapping, and military surveillance. Rudimentary spaceborne satellite remote sensing era: Spy satellite remote sensing era: During the peak of the cold war, spy satellites such as Corona Dwayne et al. Data was collected, almost exclusively, for military purposes. The data was not digital, but was produced as hard copies. However, the spin-off of the remote sensing developed for military purposes during the above 3 eras spilled over to mapping and slowly into environmental and natural resources applications. Meteorological satellite sensor remote sensing era: This was an era when data started being available in digital format and were analyzed using exclusive computer hardware and software. This was also an era when global coverage became realistic and environmental applications practical. The Landsat-6 failed during launch. These satellites have high resolution nominal 2. At this resolution, only Landsat is currently gathering data with global wall to wall coverage. This is, by far, the most significant era that kick started truly wide environmental application of remote sensing data locally and globally. Earth Observing System era: Applications of sensor data have become wide spread and applications have multiplied. Institutions and individuals who never used remote sensing have begun to take an interest in remote sensing. The new millennium era Bailey et al. These are basically satellites and sensors for the next generation. These include Earth Observing-1 carrying the first spaceborne hyperspectral data. The private industry era began at the end of the last millennium and beginning of this millennium see Stoney, This era consists of a number of innovations. Second, a revolutionary means of data collection. This is typified by Rapideye satellite constellation of 5 satellites, having almost daily coverage of any spot on earth at 6. Third, is the introduction of micro satellites, some under disaster monitoring constellation DMC , which are designed and launched by surrey satellite technology Ltd. Fourth, is the innovation by Google Earth http:

Chapter 3 : Remote sensing - Wikipedia

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on-site observation, especially the Earth.

Society What is Remote Sensing in Geography? Remote sensing is the process of acquiring details about an object without a physical on-site observation by means of satellite technology. The Mars Odyssey, used to search for evidence of water and volcanic activity on Mars using remote sensing technology. Remote sensing is the process of acquiring details about an object without physical on-site observation using satellite or aircraft. Remote sensors are mounted on the aircraft or satellites to gather data via detecting energy reflected from the Earth. Remote sensing has been beneficial to scientists who are in constant need of data as it pertains to land, ocean, and the atmosphere. History Of The Remote Sensing Technoloy The remote sensing discipline has undergone several advancements in recent years as the field of photography and the innovation of aircraft facilitated the development of the discipline. Before that, the term aerial photography was the common term used. Aerial photography at the time portrayed black and white images and new technologies and methods were emerging which promoted more detailed graphic images. Computer technology further enabled a digital form of imagery. During the s and s satellites became favored over aircraft by countries such as the US and Russia, since they could carry out monitoring on a regular basis. The system has enabled scientists to gather data from places which would not be possible to see or visit. Overview Of Remote Sensing Remote sensing can either be carried out by passive or active remote sensors. Passive sensors gather radiation from external stimuli. The primary source of energy relied upon by passive sensors is reflected sunlight. Radiometers, infrared, and film photography are examples of passive remote sensors. Active sensors, on the other hand, depend on internal stimuli for data collection. They reflect energy to the particular area, and after detection, they measure the energy reflected from the region. Examples of such sensors include the Lidar, which projects laser light to measure the distance to a target. One of the most notable satellites which have enabled remote sensing is Landsat, a project conceived in the US. Since its launch, millions of images have been acquired with far-reaching benefits to governments, scientific organizations, and businesses. It is thus essential to hazard assessment as well as the monitoring of land degradation and conservation. The system tracks wild weather, from floods, earthquakes, to hurricanes and data collected can be interpreted to analyze the destruction caused by natural disasters. Such data can be used to formulate strategies to be implemented before and after disasters. Since the system can access areas inaccessible to humans, it can monitor the impact of deforestation on significant regions including the Amazon Basin and can also map out areas that need protection. The system is particularly essential in environmental monitoring and natural resource management, and it surveys the human impact on the environment. Remote sensing is also useful in oceanography as it tracks ocean circulation, temperature, and wave heights to understand ocean resources better. The system is used in geology and mineral exploration, forestry, and agriculture. Limitations Of Remote Sensing The resolution of images produced by satellites can be too coarse to identify small contrasting areas and undertake detailed mapping. The process of analyzing data collected is complicated and cost-intensive, and measurement uncertainty is often large. The costs of running a remote sensing system can be expensive especially for small and developing countries with inadequate finances, technology gaps, and lack of trained personnel. This page was last updated on April 25, By Benjamin Elisha Sawe.

Chapter 4 : Barry's Remote Sensing Page

Remote sensing began in the s as balloonists took pictures of the ground using the newly invented photo-camera. Perhaps the most novel platform at the end of the last century is the famed pigeon fleet that operated as a novelty in Europe.

Applications of remote sensing data Conventional radar is mostly associated with aerial traffic control, early warning, and certain large scale meteorological data. Other types of active collection includes plasmas in the ionosphere. Laser and radar altimeters on satellites have provided a wide range of data. By measuring the bulges of water caused by gravity, they map features on the seafloor to a resolution of a mile or so. By measuring the height and wave-length of ocean waves, the altimeters measure wind speeds and direction, and surface ocean currents and directions. Light detection and ranging LIDAR is well known in the examples of weapon ranging, laser illuminated homing of projectiles. LIDAR is used to detect and measure the concentration of various chemicals in the atmosphere, while airborne LIDAR can be used to measure heights of objects and features on the ground more accurately than with radar technology. Radiometers and photometers are the most common instrument in use, collecting reflected and emitted radiation in a wide range of frequencies. The most common are visible and infrared sensors, followed by microwave, gamma ray and rarely, ultraviolet. They may also be used to detect the emission spectra of various chemicals, providing data on chemical concentrations in the atmosphere. Stereographic pairs of aerial photographs have often been used to make topographic maps by imagery and terrain analysts in trafficability and highway departments for potential routes. These thematic mappers take images in multiple wavelengths of electro-magnetic radiation multi-spectral and are usually found on earth observation satellites, including for example the Landsat program or the IKONOS satellite. Maps of land cover and land use from thematic mapping can be used to prospect for minerals, detect or monitor land usage, deforestation, and examine the health of indigenous plants and crops, including entire farming regions or forests. Within the scope of the combat against desertification, remote sensing allows to follow-up and monitor risk areas in the long term, to determine desertification factors, to support decision-makers in defining relevant measures of environmental management, and to assess their impacts. Acoustic and near-acoustic Passive; Sonar is used for detecting, ranging and measurements of underwater objects and terrain. Seismograms taken at different locations can locate and measure earthquakes after they occur by comparing the relative intensity and precise timing. Active; pulses are used by geologists to detect oil fields. To coordinate a series of large-scale observations, most sensing systems depend on the following: High-end instruments now often use positional information from satellite navigation systems. The rotation and orientation is often provided within a degree or two with electronic compasses. Compasses can measure not just azimuth i. More exact orientations require gyroscopic-aided orientation, periodically realigned by different methods including navigation from stars or known benchmarks. Resolution impacts collection and is best explained with the following relationship: The skilled management of collection results in cost-effective collection and avoid situations such as the use of multiple high resolution data which tends to clog transmission and storage infrastructure. Data processing See also: Inverse problem Generally speaking, remote sensing works on the principle of the inverse problem. While the object or phenomenon of interest the state may not be directly measured, there exists some other variable that can be detected and measured the observation , which may be related to the object of interest through the use of a data-derived computer model. The common analogy given to describe this is trying to determine the type of animal from its footprints. For example, while it is impossible to directly measure temperatures in the upper atmosphere, it is possible to measure the spectral emissions from a known chemical species such as carbon dioxide in that region. The frequency of the emission may then be related to the temperature in that region via various thermodynamic relations. The quality of remote sensing data consists of its spatial, spectral, radiometric and temporal resolutions. Spatial resolution The size of a pixel that is recorded in a raster image - typically pixels may correspond to square areas ranging in side length from Template: Spectral resolution The number of different frequency bands recorded - usually, this is equivalent to the number of sensors carried by the platform s.

Current Landsat collection is that of seven bands, including several in the infra-red spectrum. Radiometric resolution The number of different intensities of radiation the sensor is able to distinguish. Typically, this ranges from 8 to 14 bits, corresponding to levels of the gray scale and up to 16, intensities or "shades" of colour, in each band. Temporal resolution The frequency of flyovers by the satellite or plane, and is only relevant in time-series studies or those requiring an averaged or mosaic image as in deforesting monitoring. Cloud cover over a given area or object makes it necessary to repeat the collection of said location. In order to create sensor-based maps, most remote sensing systems expect to extrapolate sensor data in relation to a reference point including distances between known points on the ground. This depends on the type of sensor used. For example, in conventional photographs, distances are accurate in the center of the image, with the distortion of measurements increasing the farther you get from the center. Another factor is that of the platen against which the film is pressed can cause severe errors when photographs are used to measure ground distances. The step in which this problem is resolved is called georeferencing , and involves computer-aided matching up of points in the image typically 30 or more points per image which is extrapolated with the use of an established benchmark, "warping" the image to produce accurate spatial data. As of the early s, most satellite images are sold fully georeferenced. In addition, images may need to be radiometrically and atmospherically corrected. Radiometric correction gives a scale to the pixel values, e. Atmospheric correction eliminates atmospheric haze by rescaling each frequency band so that its minimum value usually realised in water bodies corresponds to a pixel value of 0. The digitizing of data also make possible to manipulate the data by changing gray-scale values. Interpretation is the critical process of making sense of the data. Image Analysis is the recently developed automated computer-aided application which is in increasing use. Object-Based Image Analysis OBIA is a sub-discipline of GIScience devoted to partitioning remote sensing RS imagery into meaningful image-objects, and assessing their characteristics through spatial, spectral and temporal scale. Old data from remote sensing is often valuable because it may provide the only long-term data for a large extent of geography. At the same time, the data is often complex to interpret, and bulky to store. Modern systems tend to store the data digitally, often with lossless compression. The difficulty with this approach is that the data is fragile, the format may be archaic, and the data may be easy to falsify. One of the best systems for archiving data series is as computer-generated machine-readable ultrafiche, usually in typefonts such as OCR-B, or as digitized half-tone images. Ultrafiches survive well in standard libraries, with lifetimes of several centuries. They can be created, copied, filed and retrieved by automated systems. They are about as compact as archival magnetic media, and yet can be read by human beings with minimal, standardized equipment. The Mars Odyssey used spectrometers and imagers to hunt for evidence of past or present water and volcanic activity on Mars. Beyond the primitive methods of remote sensing our earliest ancestors used ex.: Tournachon alias Nadar made photographs of Paris from his balloon in Messenger pigeons, kites, rockets and unmanned balloons were also used for early images. With the exception of balloons, these first, individual images were not particularly useful for map making or for scientific purposes. A more recent development is that of increasingly smaller sensor pods such as those used by law enforcement and the military, in both manned and unmanned platforms. The advantage of this approach is that this requires minimal modification to a given airframe. Later imaging technologies would include Infra-red, conventional, Doppler and synthetic aperture radar. The development of artificial satellites in the latter half of the 20th century allowed remote sensing to progress to a global scale as of the end of the cold war. Space probes to other planets have also provided the opportunity to conduct remote sensing studies in extraterrestrial environments, synthetic aperture radar aboard the Magellan spacecraft provided detailed topographic maps of Venus, while instruments aboard SOHO allowed studies to be performed on the Sun and the solar wind, just to name a few examples. Recent developments include, beginning in the s and s with the development of image processing of satellite imagery. Remote Sensing software Remote Sensing data is processed and analyzed with computer software, known as a remote sensing application. A large number of proprietary and open source applications exist to process remote sensing data. Among Western Academic respondents as follows:

Chapter 5 : History of Remote Sensing, Satellite Imagery

Read chapter 2 A Brief History of Remote Sensing Applications, with Emphasis on Landsat: Space-based sensors are giving us an ever-closer and more compre.

Page 50 Share Cite Suggested Citation: Linking Remote Sensing and Social Science. The National Academies Press. On command, all of them make measurements of the land surface, transmitting spectral data to a global network of strategically located ground receiving stations. Verne made the extraordinary prediction that a rocket would be launched from Florida by means of chemical propulsion, and that the crew would include three people and a dog. First they would only circle the moon and return to earth, as did Apollo 8. What he did not predict was that astronauts would be awed by the blue marble, or that their photographs would so sensitize the world that subsequent human scientific interest would shift toward space as a means for studying the earth. Most histories of remote sensing identify Gaspard Felix Tournachon as the first person to photograph "remotely," using balloons above Paris in Bal- loons were also used for aerial reconnaissance during the American Civil War. MORAIN 29 By , aerial photographs were being taken from airplanes for a wide range of uses, including warfare, land-use inventory, and publicity. Evelyn Pruitt of the Office of Naval Research originally coined the term "remote sensing. In the audience was Dr. William Fischer of the U. By this time, all of the principal government, academic, and private-sector motivators for an orbiting resource satellite system were represented. Among the papers in the proceedings was one by Dr. Robert Alexander from ONR. He gave the first announcement for what evolved into Landsat-l. The National Aeronautics and Space Administration is sponsoring a study of the geographic potential of observations and experiments which might be car- ried out from the remote vantage of earth-orbiting spacecraft. The investigation will involve both the value of the science of geography and the expected practi- cal applications of an earth-viewing-orbiting laboratory and other possible geo- graphic satellite systems. Early emphasis will be on problems of systematizing and managing the flow of geographic information which would result from such a program. In some cases it supported construction of laboratory facilities and supplied the equipment needed to train the s generation of Ph. By the mid- to late s, many of these young professionals were employed on collaborative fed- eral government research projects for proof-of-concept applications embracing the whole range of natural and cultural resources. While these were not the only application development programs under way, they were symptomatic of a massive spontaneous adaptation to fundamentally new ways of studying the earth. This community brought about major changes in organizational structures, became the basis for a new international research agenda, and germinated the first seeds of thought on global habitability. The proposed midget moon, or "satellite," would provide "an observation aircraft [sic] which cannot be brought down by an enemy who has not mastered similar techniques. A few months after launch, however, a presidential directive classified the Discoverer program and plunged it into deep secrecy. In ,6 years before Sputnik 1, Arthur C. This system generated the first television-like pictures of the entire globe in a systematic and repetitive manner. Over the last two decades, AVHRR data have been used to construct vegeta- tion indices for monitoring crop failures, urban climate, locust outbreaks, range conditions, deforestation, and desertification Ehrlich et al. The NOAA satellites have been important in the development of famine warning systems, such as those described by Hutchinson in this volume. These satellites are of much coarser resolution than the Landsat series discussed below one AVHRR image can cover as many as Landsat images , but the lack of detail is somewhat compensated by the broad coverage, lower costs, and more frequent twice daily flyovers. Roller and Colwell argue that the AVHRR images can be used very efficiently to stratify land use and topography for more detailed studies with Landsat and other higher-resolution satellites. At an even coarser scale, the Geostationary Earth-Orbiting Satellite GOES provides the continuous hemi- spheric coverage of cloud cover and other aspects of the atmospheric circulation shown on evening weather forecasts as a visual confirmation of approaching weather, particularly extreme events such as hurricanes. The photographs taken from manned space expeditions such as Gemini and Apollo were used in several land inventory applications. In , Skylab took more than 35, images that have become classics in many resource manage- ment and earth science texts.

In recent years the Space Shuttle has taken numer- ous images of sites of human interest, many at the request of researchers con- cerned with deforestation, urbanization, pollution, and water resource management. Americans take pride in having developed the Landsat program, as well as other, more recent civilian programs. The evolution of Landsat, however, has been neither linear nor predictable. The remainder of this chapter provides an overview of its conception, genesis, and growth; its accomplishments and current status; and its uncertain future. At this point, Landsat still dominates remote sensing applications in the United States. All of the missions conducted in the s and s, including those that acquired hand-held Gemini, Apollo, Skylab, and Apollo-Soyuz photography and the early Landsats, were approved and funded as experiments to advance space science. Earth now supports more than 5 billion people, and human populations are growing at 1. Regardless of how many people can be squeezed onto the planet, however, there are limits to the renewable and nonrenewable re- sources needed to support them. Efficient management of renewable resources and judicious use of nonrenewable resources, as well as improved conservation and protection of fragile and endangered environments, depend on timely infor- mation about, and accurate analysis of, those resources. In the late s, there was a convergence of thought that the best means for acquiring the needed data was earth-orbiting satellites that could provide continuous and nearly synoptic coverage of terrestrial resources. This would be the case in particular for under- standing and measuring earth system processes at regional, continental, or global scales. Human numbers and human impacts on resources thus became an early and globally compelling argument for studying the earth from space. While there were, and still are, many security limitations imposed on the first generation of earth- observing systems, there was nevertheless a defensible argument that such a system should be developed. It was recognized that timely information about the global distribution of critical natural resources and the factors that affect global environmental conditions is integral to national security and would be gleaned in part from civilian systems. Commercial Opportunities The U. Remote sensing technology was developed by aerospace industries under contract to federal gov- ernment agencies to satisfy both government and public needs. Commercializa- tion of this know-how is fundamental to American ideals and has been a stimulus for continued industry investment. By the early s, several industries, in- cluding communications satellites and booster launch services, had already proven the commercial value of the space environment. Full commercialization of both the space and ground segments may yet prove to be intractable, but there is clearly a viable and profitable role for industry in building space platforms, sensor systems, and ground processing facilities, as well as providing value-added data processing services. The commercial value of space- based remote sensing products and services is a hypothesis that will finally be tested with several privately owned satellites scheduled for launch in International Cooperation The U. To this end, Americans want to share benefits from space technology with other nations, but they also want to protect their commercial interests. Earth observations from space have never been the sole domain of the United States, and several nations now participate in this activity with competing spacecraft and sensor systems. While these objectives were not publicly articulated in the early s, they were a driving political force in the Landsat planning process. International Law Societies are governed by laws, rules, and regulations to maintain organiza- tion and order not only on earth, but also in space. Societies establish laws by which they govern against chaos and anarchy. Space law is relatively new to jurisprudence, but it is a central force because it sets the rules by which all nations, not just the space-faring ones, have a voice in how to participate in space technology. Legal aspects of civilian space-based remote sensing are compli- cated and sometimes controversial, especially regarding the issues of national sovereignty, rights of privacy, and, most recently, commercial gain. When the United States implemented the Landsat program, it made an extraordinary effort to ensure that every nation had access to these data, even to the extent that foreign ground receiving stations were installed. Archibald Park and others in the U. The EROS mission was to archive and distribute remotely sensed data, and to support remote sensing research and applications development within Interior. These symposia were designed especially for their Landsat- sponsored investigators to report "user identified significant results. Each of the proceedings approached pages of text and graphics, mainly detailing early application concepts and models. The Landsat program had such a powerful impact in so many arenas that it was declared operational in late after a prolonged debate among participating government agencies U. In the decades to follow, however, Landsat-1 replacement satellites were the subject of severe political uncertainty. The program witnessed a change of guard among its staunchest supporters, and the satellites were casually labeled a "tech- nology in search of an application. After a quarter- century of successful data gathering, the fate of the Landsat program remains uncertain, but the technology derived from the program continues to permeate user communities and become more complex as the applications it has spawned mature. Even as the first Landsat was being prepared for launch, conflicts in agency roles had begun to appear. That charter did not include earth resource data han- dling, processing, archiving, or distribution to a large and diverse scientific com- munity, or to an even larger group of public and private users. A Nimbus-type platform was modified to carry the sensor package and the data relay equipment. ERTS-2 was launched on January 22, Three addi- tional Landsats were launched in , , and Landsat-3, -4, and -5, respectively. They circled the earth every minutes, completing 14 orbits a day and producing a continuous swath of imagery km wide. These satellites carried two sensors: The REV sensor was a television camera designed for cartographic applications, while the MSS was designed for spectral analysis of terrestrial features. Six detec- tors for each spectral band provided six scan lines on each active scan. The combination of scanning geometry, satellite orbit, and earth rotation produced the global coverage originally suggested by Arthur C. ERTS-1 delivered high-quality data for almost 4 years beyond its designed life expectancy of 1 year and was finally shut down on January 6, Landsats-2 and -3 were decommissioned in February and March , respectively. The MSS sensors aboard Landsats-4 and -5 were identical to earlier ones. Both sensors detected reflected radiation in the visible and near -IR bands, but the TM sensor provided seven spectral channels of data as compared with only four channels collected by MSS. The 16 detectors for the visible and mid-IR bands in the TM sensor provided 16 scan lines on each active scan. The TM sensor had a spatial resolution of 30 m for the visible, near-IA, and mid-IR bands and a spatial resolution of meters for the thermal-IA band. As with all earlier Landsats, sensors on these satellites imaged a km swath. Today, Landsat-4 has lost all capability to communicate TM data and is in standby mode. Landsat-6 Landsat-6 was launched on October 5,, but failed to achieve orbit. It was similar to Landsats-4 and -5 in terms of spacecraft design and planned orbital con- figuration. Landsat-1 not only inaugurated a global research agenda, but also spawned a genre of careers in engineering and the natural sciences. Arguably, Landsat-1 provided academic geographers with real-world data for applying and testing their theoretical models, thus giving their discipline access to its first new set of spatial analytical tools since the electronic calculator. Both the American and International Societies for Photogrammetry quickly added Remote Sensing to their organizational titles as adoption of the technology produced a dramatic increase in new members and research foci. In short, Landsat-1 broadened participation and coalesced a disparate community of practitioners into an international body whose collective efforts produced a new remote sensing paradigm. Landsat-1 data became the key- stone around which the technology would adjust and grow. At that time, sensor designs spanned the electromagnetic spectrum from ultraviolet wavelengths to passive and active microwave frequen- cies. The multispectral concept combined sensors across these electromagnetic regions, and partitioned within them, to study the spectral domains of the hydro- sphere, lithosphere, biosphere, and atmosphere.

Chapter 6 : ISPRS - Historical Background

events in remote sensing history. The ï¬•rst photographs from an aircraft were taken s, to the development of satellite launch vehicles and the.

In the s, Galileo used optical enhancements to survey celestial bodies. He also used his optical equipment to observe merchant ships arriving in harbor, capitalizing on this information to modify his investment strategies to anticipate changes in the rapidly fluctuating prices of the local commodity markets. French balloonist and photographer Gaspard Felix Tournachon attempted without great success to perform land surveys in using photos taken from tethered balloons. Similar technologies were used for the next four years by the Union forces in the USA civil war, also with unsatisfactory results. In the s, Arthur Batut in Labruguiere, France affixed cameras to kites. His apparatus included an altimeter which encoded the altitude onto the film so the scale of his images could be determined. The camera shutter was triggered by a slow burning fuse, and his mechanism released a red flag when the shutter had been tripped. For all this, Batut is considered the father of kite aerial photography, a technique that persists in modern times. At least one modern preserve manager has a hobbyist interest in attaching cameras to kites for remote sensing applications, but this is still in a novelty stage of development S. Eisenhauer, private communication, By , camera miniaturization had become so advanced the cameras could be attached to pigeons. The most famous avian photographers were the Bavarian Pigeon Corps. The cameras had a mass of 70 gm 2. While their images that sometimes included wingtips in the frame were of limited use, the birds looked great in uniforms see below. What you get when you put cameras on pigeons. Note the wingtips in the top photograph! Remote sensing changed the course of world history when, during the Cuban missile crisis, U-2 spycraft detected the installation of intermediate range nuclear missiles in Cuba. Stinton discovered absorption features in his spectra of Mars that appeared to be consistent with chlorophyll. This was an interesting application of vegetation remote sensing. However, these observations were later explained as resulting from an absorption band due to deuterated water. Subsequently renamed Landsat, this was the first of the highly successful Landsat series of remote sensing platforms, the most recent being Landsat 7 launched 15 April Current remote sensing data are obtained from satellites, high flying aircraft, and low flying aircraft. Each mode of platform transport has its advantages and its disadvantages. Now that you have some history under your belt, let us review current technologies for remote sensing

Chapter 7 : What is Remote Sensing in Geography? - calendrierdelascience.com

HISTORY OF REMOTE SENSING. â€¢ Development of photogrammetric hardware (analog â€¢ Remote sensing becomes a classified technology.

Perhaps the most novel platform at the end of the last century is the famed pigeon fleet that operated as a novelty in Europe. Image pigeonst Aerial photography became a valuable reconnaissance tool during the First World War and came fully into its own during the Second WW. The logical entry of remote sensors into space began with the inclusion of automated photo-camera systems on the captured German V-2 rockets launched out of White Sands, NM. With the advent of Sputnik in , the possibility of putting film cameras on orbiting spacecraft was realized. The first cosmonauts and astronauts carried cameras to document selected regions and targets of opportunity as they circumnavigated the globe. Sensors tuned to obtaining black and white TV-like images of the Earth were mounted on meteorological satellites that began to fly in the s. Other sensors on those satellites could make soundings or measurements of atmospheric properties over a range of heights. Other nations soon followed with remote sensors that provided similar or distinctly different capabilities. The red areas on the right coincide with the high Wasatch Mountains that run east of the block-fault mountains and deserts gray-tan tones of western Utah. Immagine SaltLakeCity Other reds in small patches mark the farmlands of the desert plains. Lake Utah bluer because of silt is to its south. This image, of course, is a vertical view. To acquaint you with looking at the Earth this way, we are adding a near-horizontal aerial view of the City and the Wasatch Front to its east â€" try to relate this oblique perspective with its appearance from Landsat. We will list here the principal ones flown by several nations identified in parenthesis along with the date the first and sometimes only of each was launched. SIR-A , Note: This impressive list is convincing: Remote sensing has become a major technological and scientific tool used to monitor planetary surfaces and atmospheres. Much of this money has been directed towards practical applications, largely focused on environmental and natural resource management. The Table below elaborates on this by summarizing principal uses in 6 disciplines. The GIS approach is well suited to storage, integration, and analysis, leading to information that has a practical value in many fields concerned with decision-making in resources management and environmental control. The need to develop monitoring systems that can map changing land use, search for and protect natural resources, and track interactions among the biosphere, atmosphere, hydrosphere, and geosphere has become a paramount concern to managers, politicians, and the general citizenry in both developed and developing nations. Glossary Remote sensing Collection and interpretation of information about an object without being in physical contact with the object. Radar Acronym for radio detection and ranging. Radar is an active form of remote sensing that operates in the microwave and radio wavelength regions. Sensor Device that receives electromagnetic radiation and converts it into a signal that can be recorded and displayed as either numerical data or an image. Scene Area on the ground that is covered by an image or photograph. It remained in orbit for only a few months. Image Pictorial representation of a scene recorded by a remote sensing system. Although image is eral term, it is commonly restricted to representations acquired by non-photographic methods.

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The history of remote sensing and development of different sensors for environmental and natural resources mapping and data acquisition is reviewed and reported. Application examples in urban studies, hydrological modeling such as land-cover and floodplain mapping, fractional vegetation cover and impervious surface area mapping, surface energy flux and micro-topography correlation studies is discussed.

It is described as an electromagnetic spectrum, on which, many forms exist that describe energy in a specific region of the spectrum Fig. These are visible light, radio waves, microwaves, heat, UV rays, X-rays and gamma rays. This spectrum is an overview of the continuum of electromagnetic energy from extremely short wavelengths cosmic gamma rays to extremely long wavelengths radio and television waves. These divisions are not absolute and definite as overlapping may occur. The basic unit of wavelength, is measured in meters m. Most energy in the visible including U. Millimeters may be used for longer wavelengths blue â€” 0. Depending on the wavelength and the nominal spectral location, principal applications can be matched with suitable satellite bands for classification. Types of Remote Sensing: Thus, passive remote sensing relies on naturally reflected or emitted energy of the imaged surface. Most remote sensing instruments fail into this category, obtaining pictures of visible, near-infrared and thermal infrared energy. A multi-spectral scanner is an example of a passive system Fig. Passive visible and near-infrared data are used in a variety of GIS applications, for example in the classification of vegetation and land-use, and may be performed at a variety of temporal and spatial scales. This type of a system propagates its own electro-magnetic radiation and measures the intensity of the return signal. Thus, active remote sensing means that the sensor provides its own illumination and measures what comes back. Remote sensing technologies that use this type of system include lidar laser and radar. As for example, radar images are sensitive to the shape, orientation and size of leaves and their moisture content, rather than the vegetation color. Similarly, airborne lidars have been largely used for mapping surface topography in three dimensions. Advantages of Remote Sensing: Remotely sensed imaging systems have several advantages over camera photography, from which it differs significantly in the following two ways: Limitations of Remote Sensing: Although remote sensing has many advantages over ground-based survey, yet remote sensing has not totally replaced ground-based survey methods, largely because of some limitations with this technology, which still exist. In-spite of these limitations, remote sensing has however many advantages over ground- based survey in that large tracts of land can be surveyed at any one time, and areas of land or sea that are otherwise inaccessible can be monitored. The advent of satellite technology, and multi-spectral sensors has further enhanced this capability, with the ability to capture images of very large areas of land in one pass, and by collecting data about an environment that would normally not be visible to the human eye. Applications of Remote Sensing: Following are a few examples of some of the important uses of satellite data:

Chapter 9 : Indian Remote Sensing Programme - Wikipedia

â€¢ To operate a commercial remote sensing satellite NOAA must issue a license - the license is the 'authority to operate' - License applications are reviewed by DoD (national security purposes), DoS.