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Application of Spatial Remote Sensing for the Solution of Territorial Problems and Injustices

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Abstract: Geoinformation agglutinates information associated with different media, be they natural or artificial, such as cities or engineering projects. To generate these databases, so-called geotechnologies are used that define the principle of technological or geomatics association, highlighting among these the use of GPS, geographic information systems and satellite images. The latter have a great potential in the matter of the different spectral bands that can be applied to various situations and problems to be analyzed, highlighting pollution problems or territory planning, being able to support the repair of social injustices as well as contribute scientifically and technically to the creation of new public policies.

In this context, two case studies will be addressed, one referred to the application of images from active sensors to evaluate a problem of contamination of fuel pipes in a fishermen’s fiord, and the other to generate updated cartography to regularize the situation settlers owners of properties in insular territory.

Key words: geoinformation, geomatics, satellite image, remote sensing, cartography

1. Introduction

The use of the information provided by an integrative vision from space by satellite images, has resulted in various applications dedicated mainly to the study of phenomena and changes that occurred on the earth’s surface and which, in general, is known as geoinformation.

However, this information comes from various technologies whose current purpose is the dependence between them to achieve greater potential at the time of the most successful decision making or, from it the generation of new information more refined and reliable. Therefore, according to the objectives of the Just Side[1], project and network, we have that these technologies form a basic and essential platform for the generation of the indicated geoinformation, which will derive in more advanced principles or disciplines such as geomatics. Such technologies that constitute and shape these concepts are: satellite positioning systems or GPS [1], whose purpose is to georeference any object or element of interest on the earth’s surface with various accuracies and accuracies, as is the case of equipment GPS navigators (accuracies between 5 and 15 meters), cartographic GPS equipment (accuracies between 3-5 meters) and geodetic equipment (subcentimetric accuracies), the latter for applications in civil works, cadastre, mining measurements, borders and state boundaries, etc.. In addition, they use in common the system of cartographic representation that is more appropriate, for example, the traditional or current trend is to take everything to WGS-84 (World Geodesic System-1984), as it is a universally used worldwide geodetic system, this means that I can integrate cartographic information from a digital plane and superimpose it on a satellite image and appreciate

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[1] Justice, Sustainability and Territory Network Project through Space Data Infrastructure Systems (JUST-SIDE), of the Ibero-American Program of Science and Technology for Development - CYTED.

what the effect will be, for example, the construction of a road, the flood zone of a hydroelectric plant or the effects of a forest fire. Therefore, the appropriate location of various events, such as: property limits (high precision) or forest fire (low precision), is the starting point for, depending on the scale to be used and the type of event to be studied, Geoinformation fulfills its role of being reliable.

The second technology corresponds to the use of satellite images provided by passive sensors (depending on the sun's energy) or active (emitting their own energy beam), where the central objective is focused on capturing information of an object at a certain distance but without coming into direct contact with him [2], the concept of space remote sensing or the use of remote sensors. Unlike an aerial photograph, satellite images are formed with the energy emitted by all the elements located on the earth's surface in the form of electromagnetic waves, and which are recorded along the electromagnetic spectrum (EMF), as shown in Fig. 1, providing valuable information in sectors of the EEM where the human eye cannot act [3].

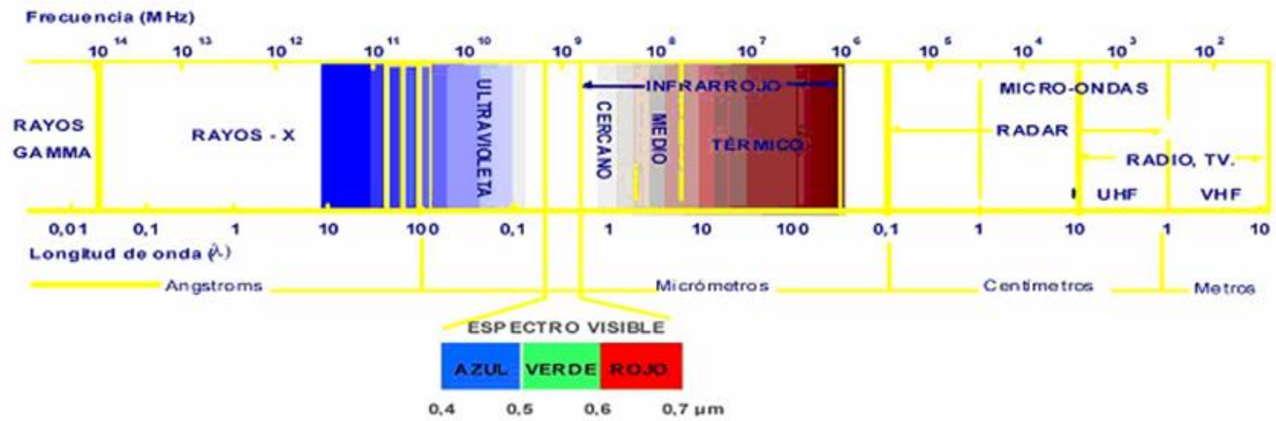


Fig. 1 Electromagnetic spectrum

Finally, we have the use of geographic information systems (GIS), a technology that completes the principle of "association of technologies", under this premise GIS have the function of integrating geo-referenced (GPS) and qualitative information delivered by images satellite, for the generation of graphic databases (maps) and non-graphic (files or records) in digital format [4], in order to be processed and generate new information according to the user's needs, for example, from A contour plane can generate digital terrain models (MDT) with 3D satellite images or create slope planes.

In this context, we have that said geotechnology association defines the principle of geoinformatics or geomatics, which was born in Canada during the second half of the last century, as a need to better dispose of the country's resources for better management and planning of the territory, resorting to a joint work between the State, companies and universities.

2. Objective

Highlight the use and applications of geoinformation and especially special remote sensing, for the analysis and contribution to decision-making on problems and injustices in the territory, showing two examples or cases with the use of active and passive sensors.

3. Methods and Results

In the current information society, although access to a huge amount of it has prevailed, preferably accessible to databases or virtual libraries directly and individually to select and analyze information of interest, the trend of integrated database management Spatial data defines a collaborative and centralized line of work, especially among tax entities such as:

ministries, universities, resource centers, etc. In addition, the technology is here to stay and the expected result is that the professional who opts for this criterion of content integration is enhanced much more, backed by an emerging discipline in our country and already consolidated in others through geoinformatics. Then, the result of this innovation finds an answer in the principle of technological association that unites, preferably, the concepts of: georeferencing, spatial analysis and integrated management of database infrastructure.

Within these geotechnologies that define the principle of geoinformation, the use of satellite images by the integrated vision of the territory stands out. These are generated by sensors located on board satellite platforms that capture the spectral patterns possessed by terrestrial objects that have the ability to emit or reflect electromagnetic energy [5], which is recorded throughout the EEM (Fig. 1). Thus its spectral differences are produced from the identifying phenotypic aspects of a class, being able to assert that a rock has its own spectral pattern, which differentiates it from other physical bodies, such as water, and from other rocks that have a different composition mineral. Associated with this, the type of algorithm, as well as the classification criteria on which the research is based, is vital to “extract” the information of interest, present in the monitoring area.

However, according to the needs of the researcher, we must distinguish between passive sensors that require energy from the sun and that correspond to those destined to studies of phenomena and natural resources. The others are the assets that emit their own beam of light or energy and that allow to capture night images and, in addition, have the ability to penetrate the cloud cover and achieve, in addition, a certain penetration into the earth’s surface. This characteristic feature of active sensors has not been explored totally and less exploited to its full potential, although technology is available and satellite images are available for commercialization, few researchers have achieved significant and substantially significant results in terms of innovation. in the areas according to the range of possibilities offered by spatial remote sensing.

Thus, the challenge of any study involving the application of this aerospace technology is to associate the digital value of the pixels that make up the different bands of a satellite image (values between 0 and 255 traditionally), with the wavelength they reflect Earth phenomena and objects. For this, knowledge of the signatures or spectral fingerprints is essential, including radiation reflected as a function of wavelength. In this way, we can define it as the peculiar way of reflecting or emitting energy from a certain object or cover, which is a consequence of the physical and chemical characteristics of the object that interacts with the electromagnetic energy, and varies, obviously, according to the lengths of wave (Fig. 2). Therefore, the spectral signatures are characteristic of a species, both of a rock (mineral), vegetable or animal, or some phenomenon or terrestrial object, which shares the same physical-chemical properties. Then, the use of these signatures or spectral signatures are the main technical-scientific argument at the time of showing dissuasive evidence of a particular situation to study, investigate or regulate, and a change in these tests in an irrefutable way an alteration either accidental or intentional.

In this way, we can obtain direct information through the use of spectral bands, knowing previously that each band reacts better to a particular phenomenon, for example, vegetation is better appreciated in the near

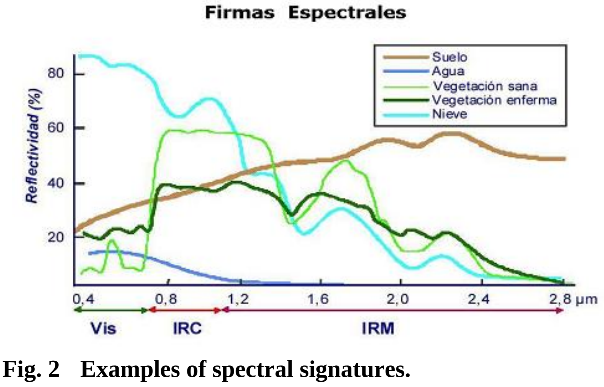


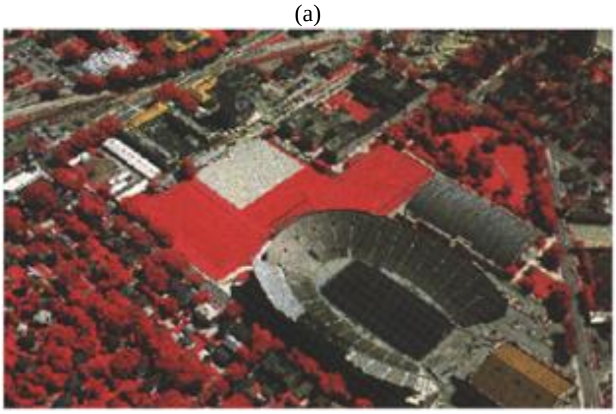
Fig. 2 Examples of spectral signatures.

infrared or IRC band [6] (Fig. 3), turbidity and depth of water in the blue band, IRT (thermal or thermal infrared), etc.

An important feature of any satellite image is the resolutions with which the manufacturer decides its use or applications in the market, these resolutions being: spatial (pixel size), spectral (number of bands), temporal (time elapsed between images for the same area) and radiometric (different levels of energy it can capture). The first is the one that attracts the most attention, since it defines the level of detail that it is capable of delivering, which we can see directly in the images of Google Earth (Fig. 4).

Then, in accordance with the type of research or study to be carried out, the type of band where the phenomenon to be studied, the resolutions that best define said element to study, the sensor or sensors that

(a)



(b)

Fig. 3 a) natural color image of the University of Wisconsin; b) the same image but with the incorporation of the IRC band, it can be seen that the stadium turf is synthetic, it did not react in the IRC band to the red color assigned to said band.

Fig. 4 Google Earth satellite image of the U. of Coimbra (Portugal).

have such characteristics and, if necessary, define the type of mathematical algorithm or function that will best help discriminate what you want to study in relation to your environment [7].

In this context, a first case study to be submitted corresponds to an academic consultancy for the evaluation of the study carried out by the Center for Remote Sensing Applied for Territorial Studies (CETAET) and whose technical report is prepared by EcoTecnos, carried out in northern Chile for the determination of hydrocarbons in groundwater and soil through multitemporal satellite images in the Las Petroleras - Antofagasta beach sector.

Historical events of possible impacts that occurred in 1994, at the beginning of 2000 and in April 2005, have reflected the presence of hydrocarbons in the study area, underground, without being able to establish the dynamics of pollution, as well as the territorial dimension of this phenomenon of environmental impact, being the main affected the neighbours, the tourist activity and the Fishermen's bay that worked there, because it has suffered from territorial information that reliably reflects both the origin and the real impact that has caused the presence of hydrocarbons at ground level. Therefore, and due to the nature of this study, it was proposed to address it through the application of Aerospace Remote Sensing techniques, through algorithms that are based on the digital analysis of radar images and the fusion of these with optical and infrared images.

Reviewing the literature related to the detection of oil on the sea surface, nowadays you can see a series of techniques that range from visual location to thermal detection using infrared (IR) sweepers, passing through aerial cameras to reaching radars synthetic opening (SAR). On the other hand, there are a series of manuals and papers [8-10], which propose the use of images obtained by synthetic aperture radars located on board satellites, being one of its objectives the generation of structure mapping underground geomorphological, because they take advantage of the transparency that some materials have in the microwave. For this reason, it was proposed to respond to the requirements requested through the application of satellite or aerospace remote sensing techniques, through the use of algorithms according to the analysis and digital treatment of radar images and the fusion of these with optical and infrared images. In this sense, the present work is based on the premise that the soil presents different spectral responses, as a consequence of its different composition and structure, derived from its granulometry, sedimentation, physicochemical components and compaction levels, which is reflected in properties differentiated dielectrics of the ground which can be captured by satellites that obtain images of different spectral resolution. Thus, the presence of water and hydrocarbons at an underground level does not go unnoticed by these sensors, which allow the generation of dynamic cartography related to the spatial and temporal evolution of these physical bodies.

In this way, the general objective was to generate dynamic mapping, relative to the presence of hydrocarbons at an underground level in the environment of the mining plant, Las Petroleras beach sector, Antofagasta, Chile; highlighting the ability to identify the existing groundwater system in the study area, establish the possible presence of hydrocarbons at the underground level and specify the volumes of hydrocarbon identified in consideration of soil granulometry. Thus, in order to establish the spectral pattern of the study area and, in this way, identify the satellite images and bands necessary for the achievement of the objectives, spectral signatures were generated in situ. For this, a hyperspectral manual radiometer was used, digitally linked with a high-resolution differential GPS network. In this way, the spectral signatures of the objects in the study area were initially identified, both inside and outside the mining facilities. Fig. 5 illustrates the results obtained in said spectral signatures.

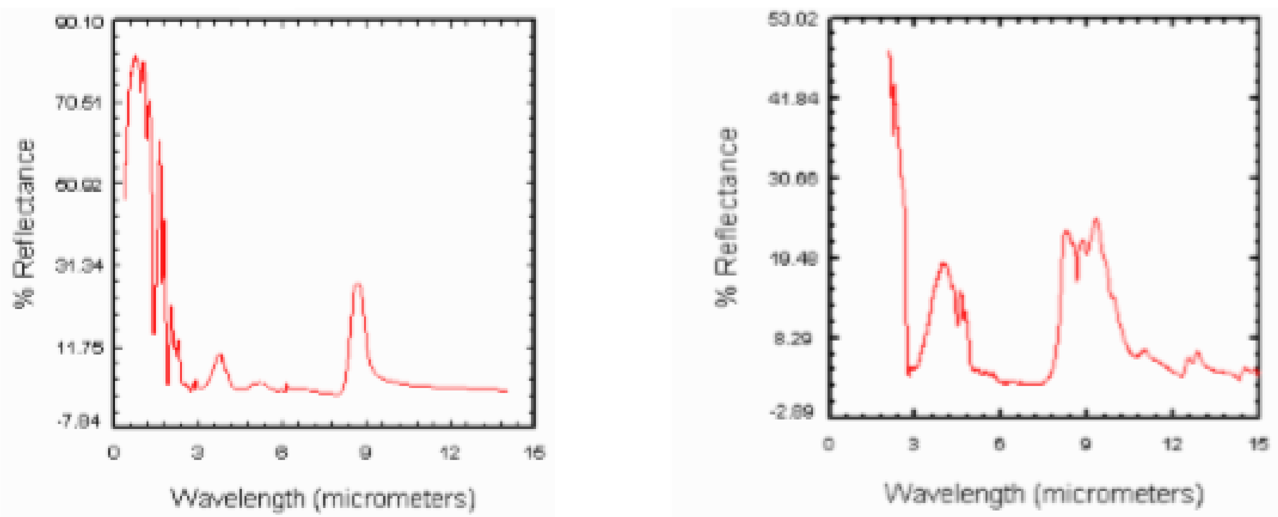


Fig. 5 Land spectral signature in the northern sector of mining facilities (left); spectral signature of the ground at the southern entrance of the enclosure (right).

Once the spectral pattern of the surface of the work area was obtained, a georeferenced spectral matrix was generated, and the satellite images necessary for the study were selected. Although, at the beginning, the exclusive use of radar images had been proposed, due to their penetration capacity in the ground, once the spectral signatures already identified were identified, it was decided to acquire images of the ASTER satellite, in order to merge them with the first.

A total of 22 radar images were used, from ERS 1 and 2 satellites, as well as from Radarsat, due to their similar spectral characteristics and the availability of the images. These were acquired on the dates requested for the study, as well as previous and subsequent dates in order to territorially identify the evolution of the hydrocarbon. As previously indicated, images of the ASTER satellite were acquired, 7 in total, due to its good possibilities of fusion with radar images and its spectral character (Fig. 6), useful for the discrimination of the geomorphological and mineral structures of the area.

In order to obtain the accuracy appropriate to the requirements of this study, the entire images were corrected geometrically or georeferenced. For this, 22 ground control points obtained with high-resolution differential GPS, in UTM coordinates, distributed over the territory using the simple stratified sampling technique were used. The ellipsoid and Datum applied was SAD-56, obtaining a mean square error (RMS) of 0.4 meters (40 cm) of positioning, which gives similar accuracy to the cartography generated according to the scale to be used.

Once the images were processed using the algorithm of nueronal networks for the detection of anomalies based on the spectral signatures identified for the presence of hydrocarbons, the fact that it did not manifest itself permanently, in the sense that if there is some filtration in the underground ponds or ducts, the infiltration of hydrocarbons into the sea should be constant.

Fig. 6 ASTER image of the bay of Antofagasta.

From the geomorphological point of view, the results obtained allow us to assert that the study area is composed of sandstones with intercalations of sediments of marine origin that cover andesitic volcanic rocks and marine sedimentary rocks of Jurassic age. It is important to highlight that they manifest as structures that are generally unconnected, generating isolated pockets, only connected at their upper levels, and the existing depressions are located at a depth close to 15 meters. It is in these cavities that the presence of hydrocarbons, water, and in some cases hydrocarbons mixed with water was identified. This area is shown in Figs. 7 and 8, here you can see how the darkest areas corresponding to the cavities are located throughout the study area.

In this way, these results were transferred to a georeferencing system, in order to generate maps of their location. The results have allowed us to have a temporary vision of the contributions of the different types of hydrocarbons to the studied area, as well as their current location and their real impact on the lives of neighbors and internal actors who live with such problems.

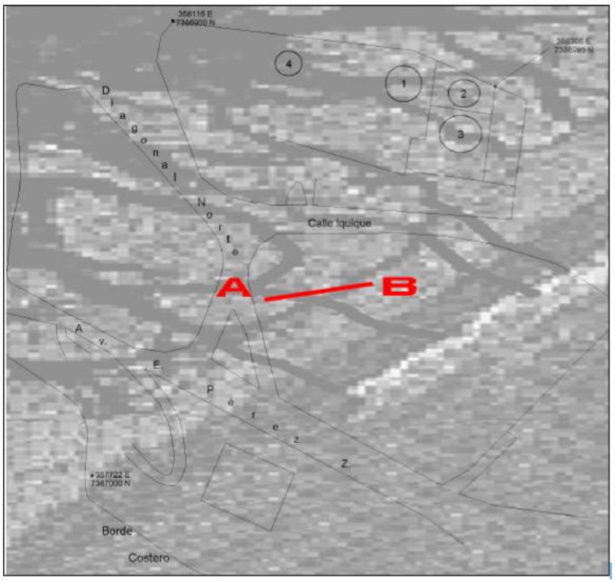


Fig. 7 Overlay of the radar image on the location map of the study area.

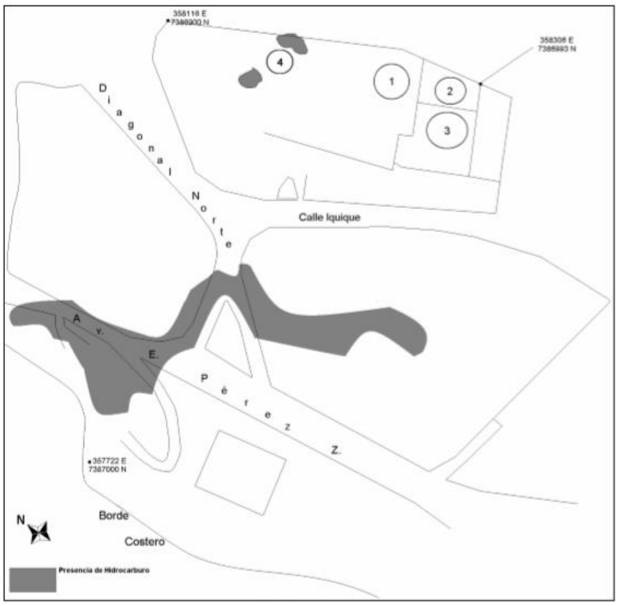


Fig. 8 Monitoring result April 2005.

Once the geomorphological structure underlying the study area was identified, as well as the effective presence of hydrocarbons, its temporal and spatial dynamics were estimated, from 1994 to 2005. The maps reflecting the evolution of the hydrocarbon to underground level. As an example, its territorial dimension can be identified in Fig. 8 in gray.

On the other hand, it was possible to notice a dynamic of territorial displacement of the hydrocarbon, which is extremely complex. For this reason we proceeded, from the remaining 15 SAR images and the support of the ASTER images acquired for this study, to determine their cause of displacement. The exhaustive analysis of this information allowed to identify that the factor that triggers this phenomenon is related to the increase in sea level, product of high and low tides, with the consequent underground displacement of sea water, which not only displaces the hydrocarbon within the structure of the underground cavities, but also, when saturation occurs, they cause a phenomenon of mass mobilization of surface materials, displacing them by gravitational effect and volume difference towards the areas near the waterfront.

Therefore, it could be said that there was a phenomenon of underground wandering, which covers a large part of the study area and is connected to the coastline, through variations in sea level.

In addition, it was possible to establish the origin of the oil that underlies the area, which would be located in the polygon that has as central UTM coordinates 357850 E and 7386650 N, and that exceeds the facilities of the mining company and, therefore, they would correspond to another oil company, according to information provided by CONAMA[2], and the Regional Ministry of Health of the Antofagasta region.

By way of conclusion, in the light of the results obtained, it is feasible to state that the origin of a large part of the hydrocarbon existing underground in the study area originated prior to 1994, in a polygon outside the plant's facilities. mining company that, as indicated above, would belong to former facilities of another oil company. This, in addition, is supported by the multitemporal monitoring carried out with radar images, merged with optical images according to the methodology applied. In this regard, it should be noted that the physical principles applied correspond to and adapt to the type of study carried out, using a methodology that traditionally proved appropriate,

[2] CONAMA – National Corporation for the Environment, and SEREMI - Regional Ministerial Secretariat, of the Government of Chile.

which was composed of four fundamental stages: measuring the phenomenon in the field with a radiometer to determine and know its spectral behavior to compare the terrain data with the digital level presented by the satellite image, georeference the satellite image to be able to empty spatial information using coordinates in a defined cartographic reference system, apply the algorithm that It is more appropriate for the study to be carried out, and verification of the process with reliable field information for the analysis and delivery of results.

On the other hand, the way in which the hydrocarbon moves and, therefore, how the process of contamination of soils and coastline is triggered, is associated with the underground geomorphology of the area, where impermeable rock causes the presence of unconnected cavities in its base, which are occupied by hydrocarbon and shared by water. Hence, the pollution events identified at the coastal level occur when these depressions become saturated with seawater carrying in the form of mass mobilization the surface materials towards the coastline, being an activity that generates environmental risks and outbreaks. of avoidable territorial injustice[3], such as: commutative injustices because the neighbors are the harmed ones and the compensations are insufficient, of the preventive type since the risk led to a serious incident causing disturbances in the lives of the neighbors and in the fishing cove, and of the remuneration type, with impunity in favor of the large mining companies in the area, which is at least unethical and where the authorities do not take corrective or sanctioning actions with due speed.

Finally, considering the evolution of the existing hydrocarbon volumes, it was also possible to affirm that its final destination is the sea, its hauling process being extremely slow, being comparable to the injustice of the restorative type, since after several years, environment damage has not been restored in an area of fiscal strip, such as a beach, and whose damage is even slower to repair.

A second case study corresponds to the area of territorial planning on Robinson Crusoe Island, whose name comes from the fact narrated in the novel of the same name known to all, and that gave rise to the inspiration of Daniel Defoe in his book published in the century XVIII. Then, the work to be presented corresponded to that developed by the Department of Geographic Engineering of the University of Santiago de Chile for the Ministry of National Assets, and shows the contribution of geomatic technologies in the cadastre of fiscal properties in Caleta San Juan Bautista, Robinson Crusoe island belonging to the Juan Fernández archipelago, located off the coast of central Chile. For this purpose, integrated use and application of high spatial resolution satellite images (QuickBird_II), the use of global positioning equipment or GPS and geographic information systems (GIS) were used. The results obtained, as a result of high-precision measurements, solved various georeference problems of the land use and occupation map of these villages, a situation not only approached from the cadastral point of view but also with the support that the bathymetric survey means carried out in the area that relate both cartographic information on and below the zero level, based on the definition of the highest tide line for the Robinson Crusoe case.

In this context, the creation of said cartographic base, supported by the use of the satellite image combined with the cartographic mosaic to be updated, allowed the formalization of the situation of irregular occupations in the urban center of Robinson Crusoe Island, whose lands were located within of the 80 meter strip, dependent on the administration of the Municipal Works Directorate of the town hall of the island, information required by the Ministry of National Assets for its future formalization. In addition, associated with the same project in Cumberland Bay

[3] Activities that Generate Environmental Risks and Spotlight on Avoidable Territorial Injustice or GRAFITE (Actividades Generadoras de Riesgos Ambientales y Focos de Injusticia Territorial Evitable) defined and used by the JUST_Side network.

(Fig. 9), an environmental risk study was conducted, in which it was possible to simulate the impact caused by a tsunami with a wave of 5 meters high on the civic center of Robinson Island Crusoe. Thus, the utility of resorting to the integration of geomatic technologies to innovate in planning urban growth in these remote places is evident.

In this way, the availability of information for territorial planning turns out to be fundamental at present, providing spatial data that contributes to a functional and reliable cadastre, so the use of remote sensors installed on satellite platforms that orbit our planet, seek to achieve said efficiency efficiently objective, contributing significantly in this case to the study, planning and planning of urban space [11]. In this context, the digital treatment of satellite images of high spatial resolution has proved to be a very useful and powerful tool when detecting and evaluating the situation of fiscal properties in a particular situation, such as the case of Robinson Crusoe Island (Fig. 9), where the Ministry of National Assets decided to update the map of land use and occupation within the 80-meter fiscal strip from the highest tide line, in order to update information related to the properties of individuals descended from the colonizers of the island that are registered in the name of the government and that would be formalized to their traditional owners. Recent studies that address and exemplify the issue of digital treatment of satellite images coincide in applying remote sensing as part of a process that promotes more efficient urban growth and ordering [3] [2], proof of this is the work done in both Robinson Crusoe, for which the utilization of the QuickBird II high spatial resolution image in its multispectral and panchromatic formats is fully adjusted.

This project considered the integrated use of GPS equipment, the digital treatment of the QuickBird II image of 0.62×0.62 meters of spatial resolution that served as the basis for property mapping and the use of the ArcGis GIS for the generation of the bases of updated cadastral data and their respective

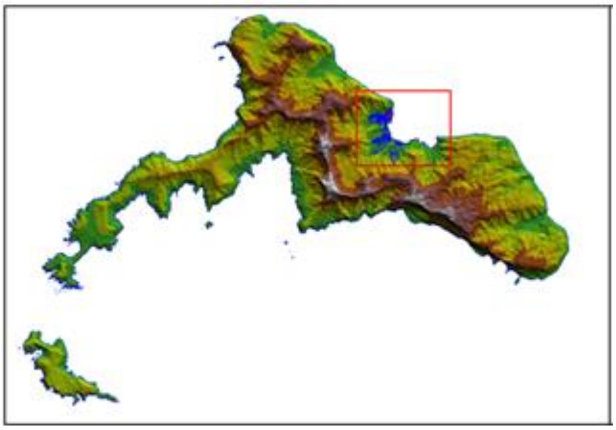


Fig. 9 Study area in Cumberland Bay, Robinson Crusoe Island.

geo-referenced plans; on the other hand, the project in Juan Fernández also incorporates a topographic survey with total station of the fiscal belt located on the highest tide line. In both cases, we worked under the principle of associated technologies already mentioned or better known as geoinformation.

The methodology consisted of the following stages:

1) Collection of cartography and acquisition of satellite images of the study area.
2) Field campaign.
3) Validation of land measurements and inventory of cadastral folders.
4) Preparation of the cartographic base mosaic to study the property to be transferred.
5) Verification of the results.

The first step was to analyze the level of reliability of the cartographic information collected, and then proceed to pick up the missing information and digitize it to contrast it with the database of the I. Municipality of Robinson Crusoe and that of the Ministry of National Assets (MBN) Subsequently, when the cartographic reality of the island was known, the field campaign was carried out which preferably consisted of geodetic support and connection with points of the Military Geographical Institute (IGM) and the Hydrographic and Oceanographic Service of the Chilean Navy (SHOA). This work also allowed obtaining control points for the geometric correction process of the satellite image and generating a reliable cartographic base for the cadastral process of properties located within the 80 meters fiscal belt that were in a transfer situation. Both the topographic survey and the geodetic support carried out had the double function of providing fresh geo-referenced data as well as their contribution to correct the overlap, turn and displacement presented by the registered and outdated plans owned by those individuals who had their land registered and in request of transfer. This aspect is relevant because there is in reality the conceptual problem of mixing procedures, accuracies and accuracies, which always leads to confusion, even when they are not clearly instructed in the technical specifications of a public proposal, then the GPS data supporting The geodetic points obtained with this global positioning system remained as base information, expanding the network with two more points called RBC1 and RBC2, however, the altimetric information was managed with total stations at the trigonometric level.

Taking advantage of the short distances and the work in cleared areas, the RTK[4] technique or real-time measurement of GPS was used for densification with new geodesic vertices, this work allowed the georeferencing of recently built properties, or of doubtful linking; However, given the presence of some areas of extreme slopes, the application of this method of real-time calculation for the entire work area was limited due to the close visibility and communication between the equipment.

Parallel to the geodetic and topographic survey on the ground, the inventory of registration plans made as part of the cadastre of the island was made, for which a work was carried out jointly with the Municipal Works Directorate (DOM) of the I. Municipality of Robinson Crusoe and the Ministry of National Assets, and consisted of a detailed review in cabinet plus the on-site inspection of the properties benefited by the cession of property by the state for those owners located in the 80-meter fiscal belt, to this was essential to know the reality of the land with the use of the satellite image for the subsequent preparation of the mosaic (Fig. 10) and, in turn, the plan of the building and the certificate of the Municipal Works Directorate, when appropriate on the situation of the property with respect to the Regulatory Plan.

With the preparation of the georeferenced mosaic with QuickBirdII images of high spatial resolution, the property information of the topographic survey of land plus the digital information of the plane of the highest tide line in AutoCad format was transferred. However, the main problem was the definition of the highest tide line and its transfer to the mosaic, although it is true that there was statistical information on tides that

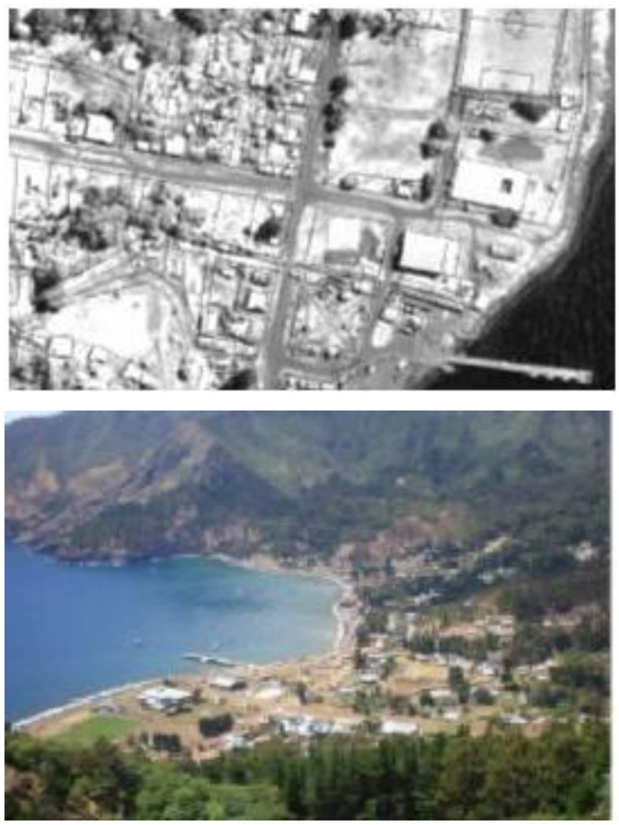


Fig. 10 View of the pier (QuickBirdII) and Cumberland Bay on Robinson Crusoe Island.

[4] *Real Time Kinematic* or RTK is a measurement method with geodetic GPS equipment, which requires a fixed station with known coordinates or geodetic vertex and one or more mobile devices that allow to materialize in the field the geo-referenced information or coordinates obtained on a surface, this It is done instantaneously according to the connectivity between the fixed station where a GPS device is left and the mobile device with accuracies that can be subcentimetric.

allowed the design of the Highest Tide Line, there were sectors along Cumberland Bay, preferably tourist and residential, which at the time of identifying them in the satellite image this proved to be difficult, regardless of the good spatial resolution it presented since in rocky beach sectors there were no fixed points of support that indicated the presence of a line that defined the highest level of a dynamic system such as tidal variation. Therefore, the georeferencing of the image performed through the control point method and topographic survey proved to be relevant in this process. To this we must add the verification and verification of the results carried out on the same ground, where photointerpretation acquired an important role, especially in the areas of cliffs or extreme slopes, here the contour lines tend to join and the definition of the Highest tide line must be made on the satellite image with the projection of identifiable points on the ground with a height equal to the highest tide line, then these points are joined in the mosaic to define the equaline of interest.

Finally, the verification and technical inspection of the results obtained in coordination with MBN professionals was carried out, this was verified in the field itself, the procedures used and the results obtained in the satellite image being approved.

Regarding the results, starting with measurements with GPS equipment on the ground, it should be mentioned that not only the properties but also the control points (GCP) were made with this technology, so the distribution and location of the GCP aimed to ensure a coverage across the satellite image and the island in order to avoid the concentration of the GCP in a particular area of the islands, which would produce a pivot effect of the image and leaving areas where control there were no GCP [2], all this was done with the purpose of being able to, subsequently, superimpose vector information on the image (cartographic mosaic). In such measurements, the distances did not exceed 5 Km of distance for which double frequency or better precision was worked.

Regarding the use of the QuickBirdII image for this type of cadastral work, it was adapted to the required accuracies, that is, the pixel size is inserted within the size of the scale of the planes managed by the Municipality of Robinson Crusoe, nevertheless, the problem was presented by the cartographic fit and identification on the satellite image of the highest tide line; Around this line coming from a dynamic system that is the variation of tides, the definition of an 80 meters strip is defined, which was essential to define for the work area, although the adjustment between: a raster system (satellite image), a vector system (polyline corresponding to the highest tide line) and the geometric correction for the cartographic adjustment should be accurate and duly checked in the field (Figs. 11 and 12).

At the conclusion of the work of this stage it should be mentioned that all the information generated in this project was duly validated, so it was necessary to take special care when trying to complement it with cartographic information from other sources, given that the complementation with another Information can present differences, especially in relation to the fit with other cartographies, differences that can be of: scale, Datum and methods of obtaining coordinates, be these topographic, photogrammetric, etc. In this context, the use of reliable cartography largely ensures efficient planning and ordering of the territory, proof of this is being able to plan on urban spaces exposed to risks of storm surge and tsunamis, of which there is no great background in the area of study, although it is recognized by the population near the sea that there are

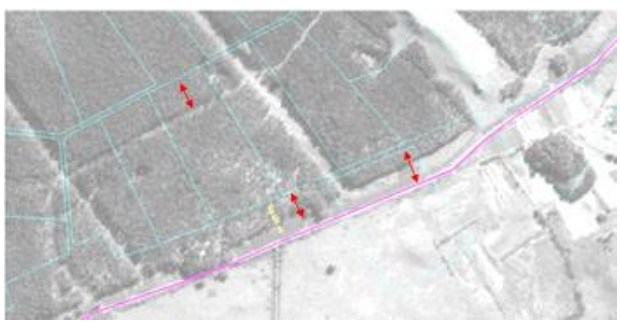


Fig. 11 Mosaic of the QuicBird II image with the cartographic predial information superimposed.

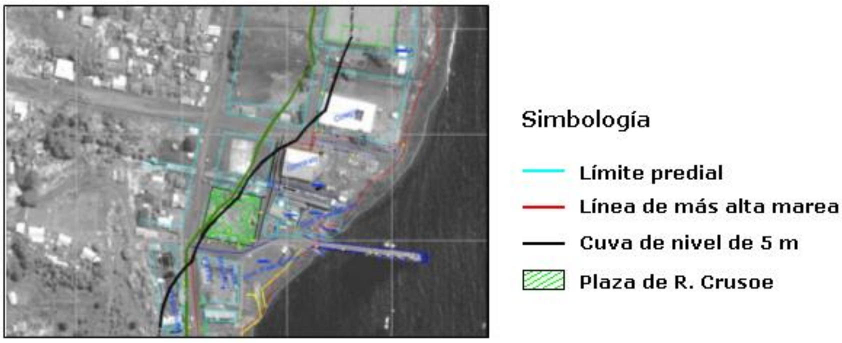


Fig. 12 Geo-referenced satellite image that indicates the layout of the 5-meter level curve (black color) that simulates the height reached by a tsunami of similar altitude and the inner urban area.

stormy periods with dangerous waves. In fact, in 1987 a storm surge affected the soccer field sector, leaving a large number of "stones" and remains of marine animals. Along with it, there were destruction in the graves of the cemetery and the radio antenna of the Port Captaincy was affected, even the area occupied by Carabineros de Chile had to be moved from the civic area to the current area of highest elevation on V. González Street. To this same event are added the destruction by the fishermen's union that lost engines and suffered the destruction of the fishermen's quarters, which are currently rebuilt. This storm surge reached a good part of the 80 meters fiscal belt, but with greater emphasis on the civic urban area.

In Fig. 12, the georeferenced satellite image shows and simulates how the 5-meter level curve, which models a tsunami of the same height, manages to exceed the limit of 80 meters to the height of the Plaza. In such circumstances, the College, the Gymnasium, the Fishermen's Office, the Port Captaincy, a Kindergarten and some commercial premises would be affected. In fact, this area was razed in the earthquake and tsunami that affected the central-southern zone and part of the island territory of Chile on February 27, 2010 with an earthquake that registered 8.8 degrees on the Richter scale.

Concluding for the present work, we have that an important aspect of the work carried out was the incorporation of a dynamic element that should be duly recognized and represented in a satellite image of high spatial resolution, as was the highest tide line on Robinson Crusoe Island. This could be solved thanks to the integrated knowledge of the geomatic technologies that allowed to project an island on an appreciable area in the satellite image that did not provide differentiable points of support (rocks, sand, cliffs).

Given the integrated nature of information managed in this project to be able to generate a reliable cartographic product, it is advisable to periodically and simultaneously update both the cartographic mosaic in AutoCad and the database that makes up the tax property committed within the range of 80 meters in Robinson Crusoe. This administrative management can be enhanced by the management of the geographic operating system properly operational by the Ministry of National Assets; nevertheless, from the point of view of activities that generate environmental risks and foci of avoidable territorial injustice, we have two relevant aspects to highlight: the first point a procedural aspect, since the administrative procedure added to the ignorance by the inhabitants of the island means that the regulation is not duly enforced to reduce environmental risks and protect the heritage, the environment with endemic species that is unique in Robinson Crusoe and the safety of its inhabitants. The other is the preventive action that must be carried out as a habitat extremely sensitive to human action (e.g., forest fires) which is unpredictable, or natural events such as tsunamis, existing protocols must be respected to avoid tragedies or irreparable losses.

Finally, an optimal planning of the territory favors the development of social, tourism and economic activities, in general, with all the productive chain that this generates. Precisely, this is where the spatial database or geoinformation infrastructure stands out as a discipline and tool that helps to optimize these regional and urban development processes.

In this way, the set of results obtained in all the processes developed for the generation of a product that can be numerical or a cartographic document, represent the confluence and integration of several disciplines associated with their respective technologies in the field of science linked to the study of phenomena occurring on the earth's surface or geosciences, where remote sensors and their product, satellite images, stand out for the delivery of information with an integrated vision of the territory and without altering the environment.

5. Conclusions

In relation to the integration of technologies that define the scope of geoinformation, we can verify through direct and highlighted examples, the direct link with the activities carried out by universities in terms of the use of satellite systems, both for georeferencing with GPS as for the digital processing of satellite images.

In this context, the success of the possible results of obtaining not only validate the objective initially proposed in a given project, but also motivate and project its implementation in this and other areas where the identification of phenomena and changes occurred on the surface earth is required in defense of our heritage and natural resources by using in the case of the use of remote sensors a non-invasive method. This stimulates the development in the integrated use of these technologies and innovation in relation to increasingly reliable applications of special remote sensing and as a technical-scientific support for the promulgation of new public policies that defend not only social injustices, but also the sustainable use of our resources and the heritage of humanity, as in the case studies presented, the first that demonstrated the contamination of hydrocarbons on a beach where there was fishermen activity (anthropic effect), and the second due to natural threat and effects of a tsunami on a civic zone in island territory.

Finally, and as part of the results obtained, it was found that against the objectives in which the present study focused, the following aspects are considered as advantages in the use of this technology with respect to traditional methods:

- The digital character of the data (the images are numerical matrices)
- The homogeneity of the data collection (the same sensor monitors the entire area)
- Ability to penetrate the images obtained from active sensors.
- The accuracy of the results, generally submetric, especially when reconsidering the information in the field.
- Carry out the study and search in a non-invasive way and in remote places.
- Technology and results validated and validable.
- Possibility of multitemporality and monitoring.
- Low relative cost.

Finally, it should be noted and emphasized once again in the process of integration of these geotechnologies and the knowledge necessary to face these changes or innovations that ultimately contribute to the fulfillment of the mission and vision of any institution of higher education, therefore, It should be aimed at an integration between: the acquired joint knowledge, the due legal framework updated to act with ownership, the resources allocated to it and, finally, have the support and conviction of the relevant authority that creates in these improvements aimed at handling of a reliable geoinformation that helps with good planning and decision making, which is verifiable in the multiple human activities and their territory.

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