REMOTE SENSING IN RESEARCH PROJECTS FROM SOUTHERN BRAZIL AND URUGUAY

SENSORIAMENTO REMOTO EM PROJETOS DE PESQUISA DO SUL DO BRASIL E DO URUGUAI

TELEDETECCIÓN EN PROYECTOS DE INVESTIGACIÓN DEL SUR DE BRASIL Y URUGUAY

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ABSTRACT
Remote sensing is an innovative technique derived from technical and instrumental advances with support capacity for several activities, including scientific research. This article describes the use of orbital images related to environmental planning activities in Embrapa, a Brazilian research public firm. 161 publications related to the period 1998 – 2025, including applications as soil surveys, environmental monitoring and precision agriculture were discussed.

Keywords: Land Use. Classification. Images. Survey.

RESUMO
O sensoriamento remoto é uma técnica inovadora derivada de avanços técnicos e instrumentais, com capacidade de suporte para diversas atividades, incluindo a pesquisa científica. Este artigo descreve o uso de imagens orbitais relacionadas a atividades de planejamento ambiental na Embrapa, uma empresa pública de pesquisa brasileira. Foram discutidas 161 publicações relacionadas ao período de 1998 a 2025, abrangendo aplicações como levantamento de solos, monitoramento ambiental e agricultura de precisão.

Palavras-chave: Uso da Terra. Classificação. Imagens. Levantamento.

RESUMEN
La teledetección es una técnica innovadora derivada de avances técnicos e instrumentales, con capacidad de apoyo para diversas actividades, incluida la investigación científica. Este artículo describe el uso de imágenes orbitales relacionadas con actividades de planificación ambiental en Embrapa, una empresa pública de investigación brasileña. Se discutieron 161 publicaciones relacionadas con el período de 1998 a 2025, incluyendo aplicaciones como levantamientos de suelos, monitoreo ambiental y agricultura de precisión.

Palabras clave: Uso del Suelo. Clasificación. Imágenes. Levantamiento.

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1 INTRODUCTION

The National Institute of Spatial Research, INPE, created in 1961 and the RADAM project, effective during the period 1970 – 1985 (Wikipedia, 2025), were perhaps, the main Brazilian entities involved with remote sensing. INPE remains active nowadays, capturing and distributing orbital images, promoting related research, and organizing, at least partially, the Brazilian thematic symposium. Orbital imagery are useful by several perspectives, by instance, coverage capacity, temporal changes, historical record and comprehensive sight. The last Symposia (INPE, 2025) included forty themes, involving disciplines as Agriculture, Geology, Meteorology and Oceanography, technical aspects as hyper-spectral remote sensing, image processing and mapping, and specific affairs, that is, climate change, fires, wetlands and soils. Furthermore, several undergraduate and postgraduate courses in Brazilian universities have incorporated the discipline of "Remote Sensing" into their curricula, deriving in associated dissertations and thesis.

This article considered 161 references related to the author, including the topics agriculture, geosciences, and edaphology, focusing a discussion about the influence of remote sensing in that context and its innovations related to socioeconomic phenomena.

2 DESCRIPTION OF WORKS

The 161 works mentioned before cover the period 1998 – 2025, being 27 technical-scientific articles, 7 books, 20 chapters of books, 39 extended or resumed abstracts in events and 68 serial publications of Embrapa, that is, 17%, 4%, 12%, 24% and 42% of total publications respectively. Since a research point of view, serial publications of Embrapa include bulletins of research and development, a structure very similar to a technical-scientific article; technical circular, technical communication and "documents", focusing aspects related to producers or a less academic public. Table 1 shows the main themes considered here and the quantity of works for each case.

"Diversified" refers to methodological studies or innovation, by instance, spectroradiometry applied to agriculture (Filippini-Alba et al., 2007) or new agricultural products, as olives (Filippini-Alba et al., 2013) and pecan-nuggets (Filippini-Alba et al., 2020). Environmental aspects related to climate change, ecotoxicology, geosciences, sustainability and the Mirim lagoon, a big water body in the Brazil – Uruguay frontier, were also involved.

Table 1

Some characteristics of the research themes considered in this article

Theme	Quantitiy	%	Description
Diversified	21	13	Several themes (see text)
Geochemistry	6	4	Chemistry of rocks and minerals
GIS	35	22	Spatial analysis and modeling
PA	22	14	Specific agricultural managing
Soil mapping	32	20	Municipality or regional scale
Zoning	30	18	Agricultural zones discrimination
Remote sensing	15	9	Change detection mapping or monitoring

PA = Precision Agriculture; GIS = Geographic information system

Uruguay was the geographical site in 8 times, Rio Grande do Sul state 123 times, Santa Catarina state 11 times, Parana state 10 times, São Paulo state 3 times and 6 times was considered Brazil or the world as a whole.

3 THE REMOTE SENSING INFLUENCE

As the Brazilian Agricultural Research Corporation, Embrapa generally focuses on rural areas. However, studies related to mineral resources and urban expansion are considered due to technical aspects or based on the author's profile, sometimes geared towards Geosciences.

Some examples related to urban expansion, soil mapping, land use, mineral exploration and cartography positioning are presented as following.

3.1 URBAN EXPANSION

Filippini-Alba e Moreira (2009) analyzed the urban expansion of some cities located near the RS122, a road located north of Porto Alegre, in the state of Rio Grande do Sul, Brazil. The images showed different expansion patterns, mainly from the year 2000, when there was an acceleration of the process. São Leopoldo grow up 55 hectares/year during 1987 to 2000 and 270 hectars/year after 2000 (2000-2007), values were 10 and 112 hectars/year for Bom Princípio, 2 and 7 hectares/year for Garcés, 32 and 77 hectars/year for Portão and 23 and 146 hectars/year for São Sebastião do Caí. The acceleration process after 2000 showed different velocities according to place, a condition related to multiple factors. Gallo (2014) describes the growth of Pelotas, Rio Grande, and Capão do Leão, cities in Rio Grande do Sul state during the period from 1990 to 2010. Several original nucleus already existed for the three cities in 1990, including the Fragata and Laranjal neighborhoods in

Pelotas, as well as Cassino in Rio Grande. So, the cities advanced to new habitable spaces after 1990s, restricted by water bodies, swamps and dunes.

3.2 SOIL MAPPING

Conventional soil mapping is based on aerial photographs interpreting (Flores; Filippini-Alba, 2015). However, few developments considered remote sensing imagery for soil mapping recently, in spite of Ikonos was the first high resolution satellite, launched in 1999, with 80 cm pixel and four bands (Apollo Mapping, 2025).

A more recent technology, the "digital soil mapping" (DSM) uses digital layers for mapping, as the digital elevation model or remote sensing imagery, besides field information, the soil-scientist knowledge and data of the profiles. So, polygons are elaborated based on digital layers, then adjusted by means of field information and the profiles data. Nachtigall (2022) applied the DSM in Marau municipality, Rio Grande do Sul state, Brazil. Soil mapping requires knowledge of the successive layers down to the bedrock. Therefore, automated mapping using surface data has not been possible until now.

Bare or sandy soils and vegetation are prominent features in remote sensing imagery, highlighting areas of mineral exploration or other types of degradation. Filippini-Alba (2018) discussed three study cases in Rio Grande do Sul state using remote sensing imagery: (1) granite exploration in Capão do Leão municipality; (2) coal mining in Candiota municipality; and, (3) sandy areas in the west of the state. Topics (1) and (2) relate to mineral sector, however, topic (3) is a natural process due to the occurrence of sandstone as basal rock.

3.3 LAND USE

Filippini-Alba et al. (2015a) compared orbital images of medium resolution, Landsat (30m pixel) and Aster (15-30m pixel), in the region of the lagoons Mirim and Patos. The main geographical features evaluated were water bodies and dunes including 25 areas of 60 hectares to more than 70 thousand hectares. The medium error was 11% (corrected value) and individual errors were less than 5% for geographical bodies bigger than 1000 hectares. Schroder and Filippini-Alba (2010) and Filippini-Alba et al. (2015b) evaluated land use on specific municipalities discriminating agricultural, environmental and urban areas.

The rice-crop area varied from 13 to 22 thousand hectares during 37 years (1973 to 2009) in Caiubá lagoon region, Rio Grande do Sul state (Filippini-Alba et al., 2012), but

variation of "pastures" and "areas without vegetation cover" was significantly greater, from 5 to 30 thousand hectares, in the same period.

3.4 MINERAL EXPLORATION

The processing and overlay of three layers derived from remote sensing data with eleven geochemical layers, discriminated twelve classes (Filippini-Alba, 1998). The remote sensing layers were TM4 Landsat band, representing vegetation, and the factor-F and factor-H (Crósta and Moore, 1989). That is, a combination of TM bands associated to iron oxides (Factor-F) and clay-minerals (factor-H) respectively. Contend of elements in stream sediments (Ba, Co, Cu, Mn, Ni, Pb, P, V, Y and Zn) and Gamma-radiometry were the geochemical layers. So, one class represented rivers and forests and two classes characterized the geochemical background, one of them with the minimal contend of trace elements and the other one, slight enriched with Co, Cu, Ni, V and Zn. Both classes, covering 56% of the research area, 28% for each, presented an intermixed spatial pattern (Filippini-Alba, 1998). Two classes appeared associated with mineralization, coinciding with geochemical anomalies derived from statistical processing, spread throughout the territory, reinforcing the possibility of mineral deposits. Finally, seven classes related to lithology, forming a large patch in the northwestern part of the research area, in the Zapican geographic sheet.

3.5 CARTOGRAPHY POSITIONING

Remote sensing imagery can be used as cartographic base, as aerial photographs were used in previous times. Anyway, there are a variety of available scales in the commercial context today, deriving on high prices and different technical aspects.

4 CONCLUSION

Remote sensing is a broad discipline encompassing applied, exact and life sciences, however, with potential for commercial and management activities too. Land use excels as the main application of remote sensing, including urban expansion. Soil mapping, mineral exploration and cartography positioning are more specific applications and they utilize the location advantages of remote sensing, functioning as a supporting discipline and a source of complementary information. The spectral properties of remote sensing have been only

partially explored to date; perhaps further progress in this area can be expected in the coming years.

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