Fostering cooperation between Spain and Portugal in the Copernicus land domain:

technical reports as outputs and results for the action

Framework Partnership Agreement
for Copernicus User Uptake

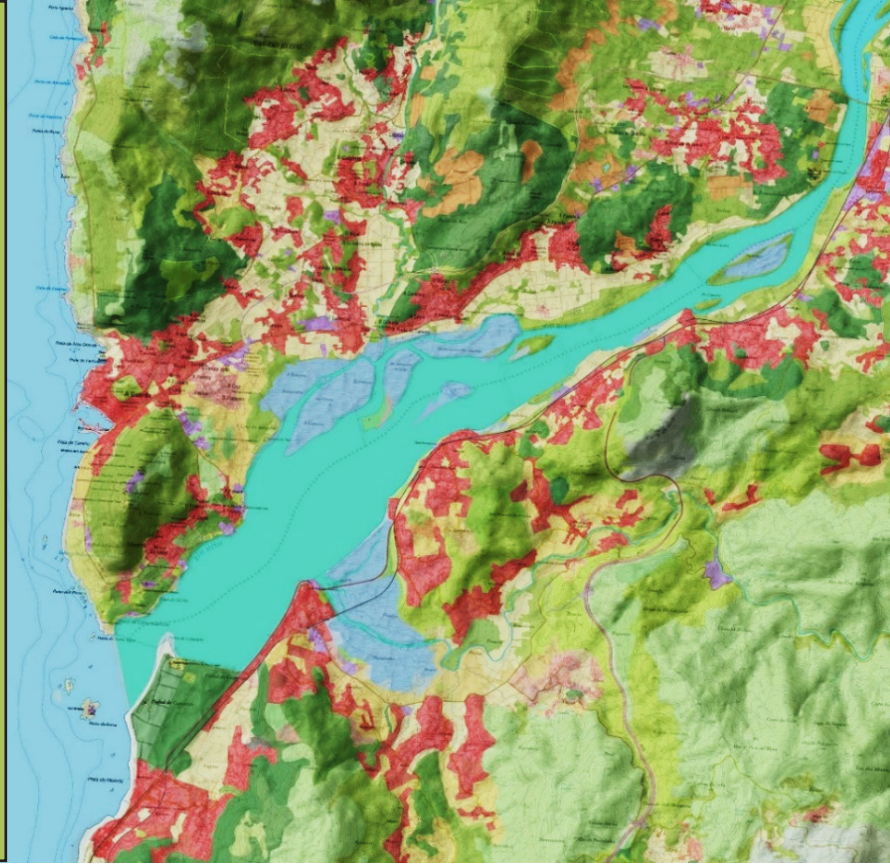
Fostering cooperation between Spain and Portugal in the Copernicus land domain

Direção-Geral do Território

GOBIERNO DE ESPAÑA
MINISTERIO DE TRANSPORTES, MOVILIDAD Y AGENDA URBANA
INSTITUTO GEOGRÁFICO NACIONAL

Land Cover and Land Use report

Participation of National LCLU data in Spain and Portugal in the Copernicus Land Monitoring Service



1 Introduction

Framework Partnership Agreement on Copernicus User Uptake is the EU-funded project that aims to enhance the user uptake of Copernicus data and products. Direção Geral do Território (DGT) of Portugal and Instituto Geográfico Nacional /Centro Nacional de Información Geográfica (IGN/CNIG) of Spain participated in the project with a particular action to promote dialogue and user uptake in the Copernicus Land domain between relevant agents and responsible national institutions in both countries.

Among other objectives, this action looks for a better coordination and articulation between Copernicus and national LCLU products in Portugal and Spain, including an exchange of experiences and best practices on the uptake of Copernicus land monitoring services and Sentinel images and its relationship with national initiatives on land cover/land use monitoring at national level.

This report describes current scope on the matter, exchange different visions from both countries and helps in the understanding of the relation between national and continental data.

2 Experiences in the verification of Copernicus Land Monitoring service products

SPAIN

Local Component 2018

The validation of the local component products 2018 version was undertaken by IGN/CNIG, in order to assess the quality of these products for the National users. The local component products validated were: Urban Atlas, Riparian Zones and Coastal zones.

The validation process consisted in a visual interpretation of polygon samples by comparison with the orthophoto with reference date 2018 (+/- 1 year) and National thematic auxiliary information as cadastral information, National Topographic Database, National LCLU Information System (SIOSE), CORINE Land Cover 2018, National geospatial reference information on Settlements, Hydrography and infrared Sentinel images of the reference year.

The three layers have very similar results with acceptable results in the thematic accuracy, good results in the detail of delineation and positional

FPCUP Action 2019-2-31: “Fostering cooperation between Spain and Portugal in the Copernicus land domain”

accuracy and bad results in the correctness of the delineated area.

Class	Samples	Thematic accuracy (%)	Detail of delineation (%)	Correctness of delineated area (%)	Positional accuracy (%)	Look feel Note (%)
Coastal zones	3.179	76,16%	86,82%	40,13%	99,37%	75,45%
Riparian zones	2.551	72,52%	96,82%	66,52%	97,77%	72,29%
Urban Atlas	4.802	74,50%	92,33%	66,46%	93,36%	74,17%

***Figure 1**: Results of the local component products 2018 in Spain*

CLC+ products

The validation of CLC + products has been done over the Backbone raster and vector products. The process had two parts in both cases: the general overview, to provide a general feeling about the data quality, and the look & feel process, based in a manual contrast with reference data over a sample of polygons.

For the raster product, the general overview has been done comparing this layer with a simulated Backbone (SBB) layer created from the information provided by SIOSE and additional national thematic information. The overall coincidence of these layers has been 71,76%.

***Figure 2**: General overview comparison of results CLC+BB raster vs SBB*

In the vector product has been done comparing the codes of SIOSE polygons centroids with the layer CLC+ polygons. The overall coincidence of these layers has been 47,0%.

The look & feel process for raster product is done by the photointerpretation of a random sample of polygons over the reference images. For raster product there were 1079 polygons (from 1 to 200ha) and 441 samples in a stratum prepared for each class with potential omissions and commissions. The process got an 86% overall thematic accuracy for raster layer. For the vector product, also a random guided sample of 3.630 polygons have been photo-interpreted with a 65,81% overall thematic accuracy.

Overall accuracy: 47,00%

- Conversion SBB into CLC+ BB vector nomenclature (using multiple assignations, 1st, 2nd,3rd)
- Comparison between SSB centroids and CLC+ BB vector
- Assessing points overlap between both layers.

***Figure 3**: General overview validation for CLC+BB vector*

Results show that raster product provides a closer accurate solution for the landscape description instead the vector one, that even generated unexpected delineation of geometries carrying out with uncertainties in the land description.

PORTUGAL
Local Component 2018

The 2018 local component products validated by DGT were: Urban Atlas, Riparian zones, Coastal zones and Natura 2000. Validation process was performed using a reference database sample of points that were visually interpreted using a time series of ortophotomaps with the aid of monthly Sentinel-2 satellite imagery and other ancillary products. The sampling units were randomly generated and stratified by the products class and by the area extension of each product.

Product	Thematic classes	Sample size	Overall Accuracy (%)	Confidence Interval 95% (%)	Level of agreement (COS) (%)
Urban Atlas	27	390	66,8%	3,1%	-
Riparian zones	55	556	63,4%	2,9%	61,4%
Coastal zones	71	592	64,4%	2,8%	63,3%
Natura 2000	55	450	68,9%	2,1%	60,1%

***Figure 4**: Results in Local components 2018- Portugal*

The overall accuracy of the local component products is in the region of 60% being the Natura 2000 the highest (68.9%) and Riparian zones the lowest (63,4%). However, confidence intervals range from 2 to 3%. The level of agreement performed with the National Land Use Land Cover (COS) map shows values slightly above 60%.

CLC+ products

Considering CLC+ Backbone raster and vector products, DGT has only validated the first one. CLC+ Backbone

raster is a categorical map with a 10m pixel resolution and a thematic detail of 11 classes.

Considering this, a set of 1140 sampling units were generated and a validation process similar to that applied for the local component products was carried out but adapted to the product nomenclature. An overall accuracy of 72% is obtained for the mainland Portugal territory with a confidence interval of 2,9% at 95% level.

High Resolution Layers 2018

The Pan-European 2018 High Resolution Layers were validated by DGT, including the Imperviousness, Forest Tree Cover Density, Forest Dominant Leaf Type, Grassland and Water & Wetness.

The accuracy assessment was performed following the method previously applied for the local component products, varying the number of samples according to products thematic characteristics. Some products have continuous nature (0-100%), and an adjustment was made to the accuracy assessment process, in particular for the Imperviousness and Tree cover density.

Therefore, a window of 5 by 5 pixels were applied for the reference database visually interpretation and the results were grouped in classes of percentage values intervals forming 5 or 10 classes according to the degree of aggregation.

Product	Thematic classes	Sample size	Overall Accuracy (%)	Confidence Interval 95% (%)	Average User Accuracy (%)	Average Producer Accuracy (%)
Imperviousness (5 classes)	-	3800	97%	1%	59%	48%
Imperviousness (10 classes)			96%	2%	40%	36%
Tree Cover Density (5 classes)	-	3080	69%	3,5%	66%	52%
Tree Cover Density (10 classes)			58%	3%	43%	36%
Dominant Leaf Type	2	840	77%	2,5%	69%	72%
Grassland	1	780	86%	2,5%	79%	75%
Water & Wetness	5	2400	99%	0,5%	69%	71%

***Figure 5**: Portuguese pan-European Local components 2018 results*

The HRL products with best overall accuracy are the Imperviousness and Water & Wetness, while the worst values are reported for the Tree Cover Density.

However, the results observed for Water & Wetness and Imperviousness should be evaluated with care because they are strongly influenced by zero values, i.e areas without Water or Wetness and areas without built-up.

For this reason, it was calculated the average user and producer accuracy, which shows not so great results, with accuracies below 50% for the 10 classes of Imperviousness and Tree Cover Density. Results are more satisfactory for the remaining products with the highest user and producer being reporter for the Grassland HRL.

3 National dissemination of Copernicus Land Monitoring Service products

CLMS products for mainland Portugal will be made available in the Portuguese National Spatial Data Infrastructure (SNIG portal[1]), by August 2023. The products already available in the portal are: Urban Atlas 2006 and 2012, Riparian Zones 2012 and Natura 2000 locations. All the products are available via WMS service and direct download in the official coordinate system for mainland Portugal. CLMS products could also be made available in the future by including them in the SMOS viewer, the viSMOS.

National dissemination of CLMS products by DGT has also been performed through courses held within the scope of other FPCUP activities in which DGT is a participant. Three online training sessions were carried out in late 2021, where a participation of more than 500 people was registered including users of SMOS (guSMOS) and users from the Public Local and Central Portuguese Administration. Other courses in the scope of FPCUP that include a CLMS product component are planned to take place between 2023 and 2024, including Copernicus Land products course, an event about CLMS products related to the forest theme and other event related to the agriculture theme.

Also for Spain some adaptation of CLMS products were performed in order to be more in line with national users' needs. They are available from the CNIG download centre[2]. HRL raster products has been published into national projection. Vector products are also available but only disseminated as CLMS portal does, without changing their characteristics.

1 https://snig.dgterritorio.gov.pt/
2 https://centrodedescargas.cnig.es/

4 National Collaboration Programme

Once CLMS products are openly accessible through European or national nodes the main issue becomes to their utilization assessment and getting feedback from users. With this objective the EEA launched in 2022 the National Collaboration Programmes (NCP) mainly focused on the user uptake and application users understanding. Along 2023 is set to define, in a co-creation dialogue among EEA and EIONET countries representatives, the main aspects for the programme in each national case. To foster a user uptake strategy in a country will be always supported by national representatives and experts, however this programme should reach to achieve other more interesting aspects for countries.

- Do not overlap or similar activities just being doing by countries in others European initiatives and financial channels. For example, with the Framework Partnership for Copernicus User Uptake.

- Re-use official national for producing and validation CLMS products, in similar manner than NCP defined for other Copernicus services, such as the Marine Service.

This last aspect has been omitted in the first conception of the NCP by the EEA, however, means a strategic facet for the national interest and participation in the programme. From last years the role and participation of countries in the production of CLMS has been reduced in favour of private sector. Current production scheme provokes misalignments between official national and continental data, possible not coincidence of reporting procedures and finally could provoke interest loses from national users. An NCP should consider bidirectional contribution, from and to CLMS and countries.

Benefits for national contributing to CLMS is dual, for national data providers and Copernicus. National data providers can find a proper way and prime user on CLMS to put in value their official data, because them will be used for continental assessments, reporting or EU policy affairs. For CLMS make use of official national data strengths their capability and helps in the data maintenance without charges for their sides. Sharing data among both contributes is a coordination of public administrations looking for an adjustment of environmental reporting, at national and at continental levels, without bias, because both use same data origin. Unfortunately, this framework it is not always possible, mainly provoked by technical limitations, no-existence of national data, data license terms and even willingness. However, this approach should be reinforced whenever technologically possible. European contracts for CLMS products creation or validation should consider the strategic importance of official national data and incorporate them in the production channels, as long as countries were able to provide data in terms of CLMS needs.

5 National Land Cover and Land Use data

SPAIN

High resolution SIOSE

The High Resolution SIOSE (HR SIOSE) is a cooperative and decentralised project between the National and Regional Administrations, being coordinated by the IGN Spain.

HR SIOSE integrates information from land cover and land use databases of different Spanish public administrations at the national and regional level with a high level of automation which allows for objectivity, cost reduction, more frequent updating and maintenance of responsible geometries and themes. The main geometrical reference source is the Cadastre, from which the delimitation of plots and buildings are integrated. It is also important the information from the Spanish Land Parcel Information System and Common Agricultural Policy farmers' declaration, the Spanish Forest Map, topographic databases Regional data and information derived from land observation such as LiDAR.

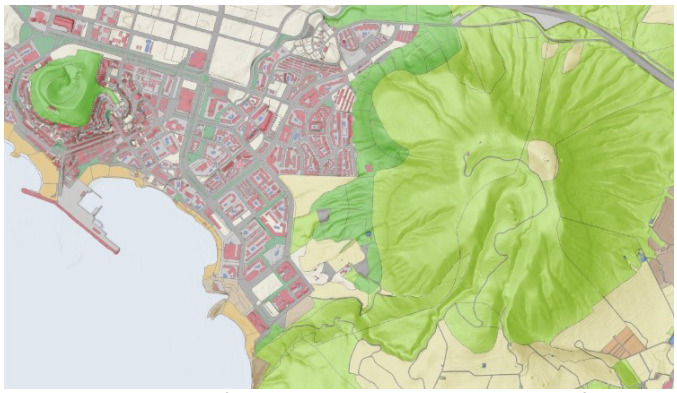


***Figure 6**: Example of SIOSE data (Los Cristianos-Tenerife)*

The production scheme has two main phases. The first one consists of the integration of the official sources through automatic processing, carried out by the IGN Spain and the second one consists of a visual review of the automatic results for validation, correction or improvement by the rest of the project collaborators, as the regional administration.

Final product is a very detailed land cover and land use information system able to describe accurately and deeply the Spanish landscape for all thematic domains. Data are freely accessible without restrictions under CC-BY license at CNIG download centre.

For more information in the project webpage[1].

PORTUGAL
SMOS

The Portuguese land cover monitoring system SMOS (Sistema de Monitorização da Ocupação do Solo) is an initiative conceived and developed by DGT with the aim of continuously produce reference and thematic cartographic products on land use land cover for continental Portugal. SMOS is a collaborative and multifunctional system that involves the Public Administration, the national scientific and technological system, the private sector and the citizen, guided by user needs and open data policy.

The National Land Use Land Cover official map for the continental territory, known as COS, (Carta de Uso e Ocupação do Solo) is part of the SMOS products. It is produced through photointerpretation of orthophotos and manual delimitation of polygons with a minimum mapping unit of 1 ha. To address COS limitations a number of new products based on Sentinel-2 data and Artificial Intelligence have been developed and implemented under SMOS initiative. One of such products is a mosaic of Sentinel-2 images to provide every month a cloud-free view of the whole territory in true and false colours composites. LULC cartography includes a new map called COSc (Carta de Ocupação do Solo Conjuntural), which is an annual land cover map in raster format based on automatic classification of multi-temporal and multi-spectral Sentinel-2 data with Artificial Intelligence. Other available products are the MIAEV (Mapas Intra-Anuais do Estado da Vegetação) which is a set of raster maps produced every month from the Normalized Difference Vegetation Index (NDVI) to represent the current vegetation greenness and how it compares to the past. Another product, MACAT (Mapa Anual de Culturas Agrícolas Temporárias), is an annual raster map identifying more than 30 annual crops based on automatic classification of Sentinel-2 data.

All these products are easily accessible on the internet through viSMOS (the geospatial viewer of SMOS) and WMS downloading services available at the Portuguese National Spatial Data Infrastructure (SNIG). There is also the COScid viewer, which incorporates a simplified version of COS enabling users to perform data exploration without having GIS knowledge. A third viewer, the COSvgi, is also available allowing for users to contribute with volunteered geographic information. The SMOS project website[1], hosts all the viewers and is the main interface between the system and the public.

The major advantages of the products CLMS products, such as the range of products and its detailed thematic and spatial level, has also enabled its utilization to improve and extend the SMOS products. One example is the use of these products in conjunction with national products to improve the technical specifications of the new COS map, allowing the minimum cartographic unit to decrease to 0.5ha.

SMOS has recently entered in a new phase of evolution, which translates into improvements to existing products and expansion of the range of cartographic products. A LiDAR coverage of mainland Portugal with 10 point per square meter density which in addition to the production of a high-resolution digital terrain model will provide derived LULC products such as point classification and orthophoto acquisition. A Very High Spatial Resolution) satellite coverage for mainland Portugal is also foreseen, with images better than 50cm pixel size. This coverage will serve as a baseline for the future new edition of COS, also allowing to explore other applications that the Sentinel-2 spatial resolution does not allow, such as monitoring urban–rural interface, monitoring fuel management bands or landscape transformation programs for fire prevention.

1 http://www.siose.es/

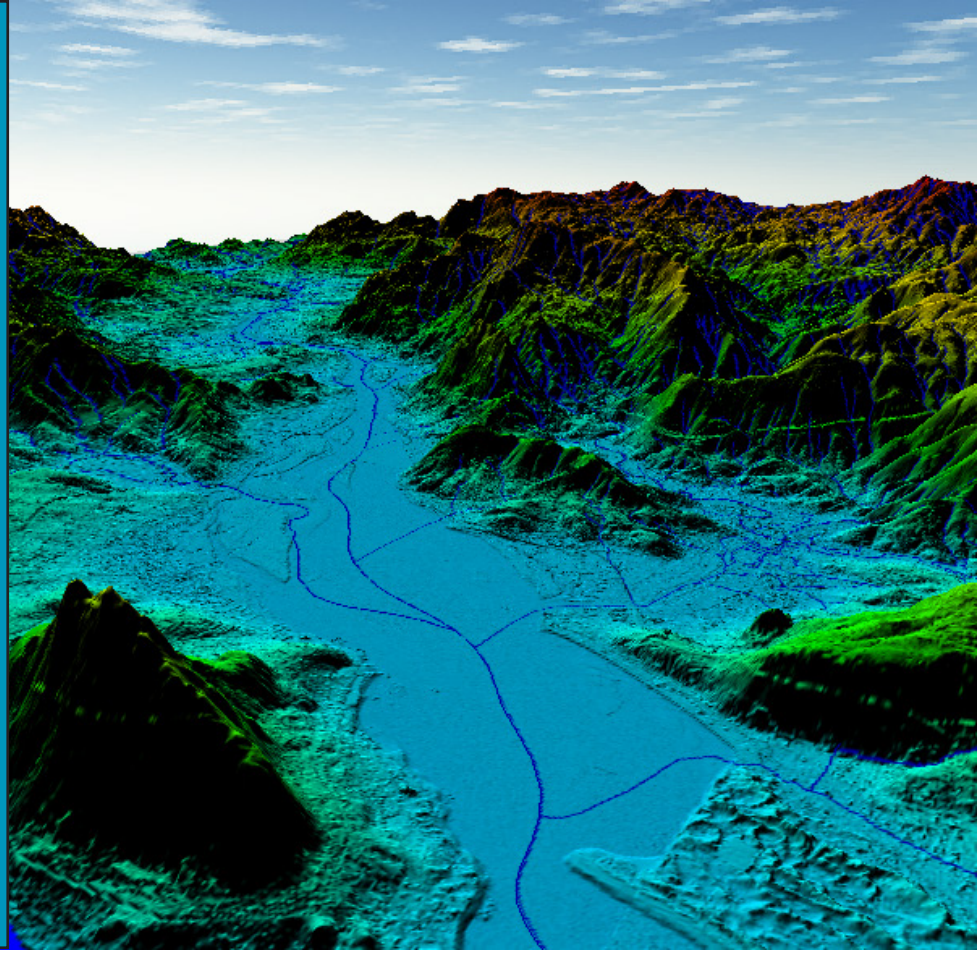
1 https://smos.dgterritorio.gov.pt/

Acknowledgement:
Delgado, J.[1], Porcuna, A.[1], Benevides, P.[2] and Marcelino, F.[2]

1 IGN Spain
2 DGT Portugal

Water in situ data report

Summary of national hydrography data available in Spain and Portugal and European Copernicus data needs



1 Scope. Water, an essential resource

Water is a common good, life cannot be hold without water, it is a differential fact that makes Earth habitable. Indeed, the first human civilizations were settled close to places where this resource was ample, and most current cities have been built near a river or coast.

Human civilization is currently facing the greatest challenge for its survival, climate change accelerated by its own action, and environmental degradation. On one hand, extreme droughts, and on the other, catastrophic torrential rainfalls, are consequence of this climate change, which will be stressed in coming years. In order to face this challenge, a European Green Deal[1] has been reached with the aim of transforming the EU into a modern economy, efficient in the use of resources and competitive, adapting policies on climate, energy, transport and taxation. As an example, the Water Framework Directive (WFD)[2] focuses on ensuring good qualitative and quantitative health, i.e., on reducing and removing pollution and on ensuring that there is enough water to support wildlife at the same time as human needs.

All these reasons, make it obvious the need of a common an interoperable hydrographic information at European level, with the best quality as possible, to use it in decision-making, resource knowledge and risk management to approach these challenges.

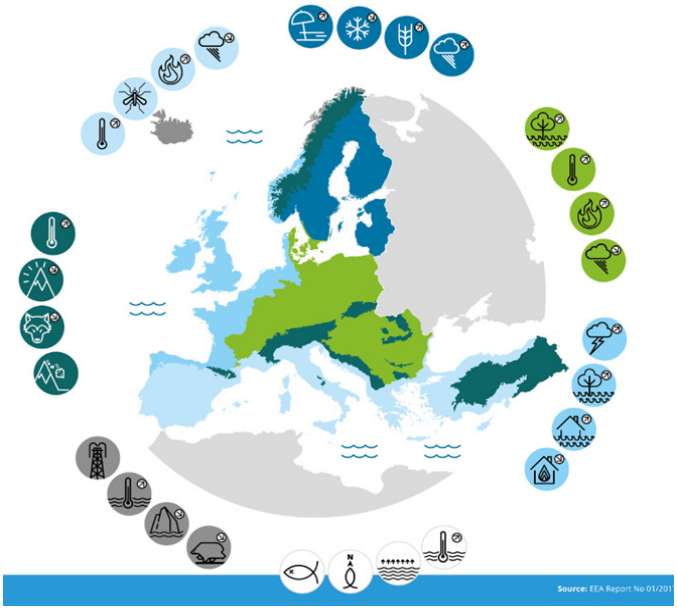


***Figure 1**: Climate change impacts in Europe´s regions.*

Source: EEA Report nº1 2017

1 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

2 https://environment.ec.europa.eu/topics/water/water-framework-directive_en

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2 Hydrography in situ data in terms of Copernicus

The Copernicus Services rely on a combination of satellite data and environmental measurements, collected by data providers external to Copernicus, from ground-based, sea-borne or air-borne monitoring systems, and geospatial reference data. In situ data are used to calibrate, verify and supplement the information provided by satellites, which is essential in order to deliver reliable and consistent data over time.

The Copernicus In Situ Component[1], coordinated by the European Environment Agency (EEA), includes contributions of the Member States to the Copernicus program, as a significant part of the data and monitoring infrastructure is owned and operated by national governments. The task of this Copernicus Component is to discover the in situ data on landscape, compare what is available against requirements to identify gaps, support the provision of cross-cutting data and manage partnerships with data providers to improve access and use conditions.

Copernicus Reference Data Access (CORDA[2]) aims to improve the access to and fitness for purpose of essential reference data for Copernicus services. CORDA is an interface and single entry-point node hosted and maintained by the EEA to facilitate quick and easy exploration and access to the national and/or regional geospatial reference data in the EEA-39 countries that have established free of charge web services. CORDA is the main gate to make public official and reference Hydrography data for Copernicus Services and its remarkable the willingness of data providers to contribute with its data.

CORDA is not the unique channel to accessed reference data in Europe. INSPIRE Directive 2007/2/CE aims to create a European Union spatial data infrastructure for the purposes of EU environmental policies or activities which may have an impact on the environment. Since its establishing, INSPIRE Directive enables the sharing of environmental spatial information among public sector organizations, facilitate public access to spatial information across Europe and assist in policymaking across boundaries. INSPIRE is based on the infrastructures for spatial information established and operated by the Member States of the European Union. The Directive addresses 34 spatial data themes[1]needed for environmental applications, where Hydrography is highlighted as ones of the main thematic content. The confluence of reporting among INSPIRE, CORDA, WFD and other environmental initiatives is fundamental for a right data provision and knowledge in a European country.

INSPIRE Directive has been reinforced by the Directive 2019/1024 on open data and the re-use of public sector information that sets a framework for the distribution of data managed by the public sector in the European Union.

Not only at continental level there are efforts for coordination and sharing geospatial data for thematic areas. Globally and under the umbrella of United National the Global Geospatial Information Management (UN-GGIM [2]) plays a leading role in the development of global geospatial information and promote its use to address key global challenges.

3 Description of National product

SPAIN
GRI on Hydrography (GRI-HY)

The main objective of the GRI-HY project at National Geographic Institute (IGN) of Spain is to provide any hydrographic phenomenon of interest in a precise, unique and standardized way, for becoming the basic data handled for all users in many fields of application. These data must be produced by an authoritative organization to ensure their maintenance over time and guarantee their quality, homogeneity and official status, and must meet both INSPIRE and the WFD, and any other national requirement.

To this aim, the IGN Spain began the automatic production of a vectorial river network from the LiDAR coverage of the Spanish territory with a density of 0.5 point / m2. From the point cloud a Digital Terrain Model (DTM) is obtained, becoming the input for a direction and accumulation raster to create automatically afterwards a river network. Reservoirs contours have been extracted

1 https://insitu.copernicus.eu/spatial-data
2 https://corda.eea.europa.eu/

1 https://inspire.ec.europa.eu/Themes
2 https://ggim.un.org/

from LiDAR data at a constant z value taken as the normalized maximum level (NMN), together with a 3D orthorectification with the NMN value. Afterwards several quality controls are carried out to ensure consistency.

During the last 3 years, a big effort has been done, together with the Water General Directorate (DGA) of the Ministry of Environment, Ecologic Transition and Demographic Challenge and the River Basin Districts Authorities in order to harmonize the geometries of the Surface Water Bodies (polygons, lines and network) for the 2021-2027 WFD report. This means the consolidation of 90.000 km of the hydrographic network at the national level. In the following years, the objective will be to achieve full harmonization.

This GRI-HY will be available for public use during this year. Meanwhile it can be consulted in this viewer. GRI-HY river networks offers an accuracy of 2-3m on xy and 0.5m on z, better than other networks available in Copernicus framework, such as EU-Hydro with 6-10m on xy and >2m on z. As a result, GRI-HY is offered to be considered in the EU-Hydro production, updating and validation processes.

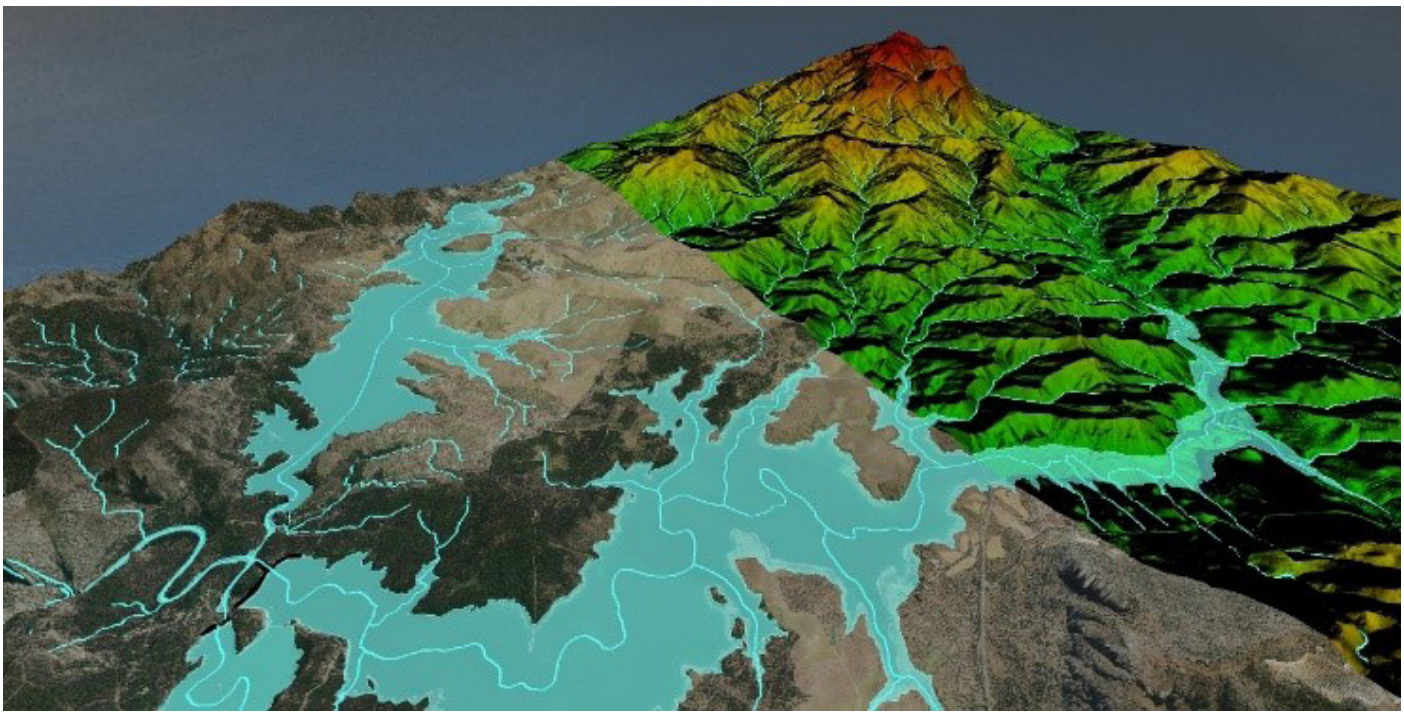


***Figure 2**: LiDAR DTM, 3D orthophoto, river network and reservoirs at the junction between Guadalhorce and Gudalteba River (Andalusia. Spain)*

PORTUGAL
Core Cartography Data

The Hydrography reference data in Portugal is produced, at a national level, by the Centro de Informação Geoespacial do Exército (CIGeoE), the military entity which produces the 1:25 000 scale map for Portugal. Besides these data, Direção-Geral do Território (DGT), the national mapping agency, also promotes de production of hydrography data in collaboration with the municipalities. The municipalities use these data in their several activities, including the spatial planning instruments they regularly produce.

DGT is now promoting the development of a national database which will include reference data of several main themes, including the Hydrography theme. This database, called Base de Dados Nacional de Cartografia (BDNC), Cartography National Database, has been established in a Portuguese Decree-Law (DL 130/2019, August 30th) and will be coordinated by DGT with the municipalities' support. All data included in this infrastructure will be completely open and free of charge. This strategy was established to increase the use of spatial

data in Portugal by those who need these spatial data to develop their professional activities and also by the citizens for their personal use.

***Figure 3**: Portuguese official core cartography themes, to be included in the Portuguese Cartography National Database (BDNC).*

At a national level, Agência Portuguesa do Ambiente (APA), the Portuguese environment agency, is a main user of hydrography data for developing their activities. Therefore, in the past they produced the hydrography data for their needs, including the report for the WFD. For this purpose, they created a digital terrain model using the altimetry data provided by CIGeoE and afterwards they generated the Hydrography data that is now being used for report purposes. This methodology allowed to have a geocoded hydrographic network that meet 3 premises:

1. Unique code - unambiguous identification of each watercourse;

2. Topological location - relative position of each section in relation to the one it flows into;

3. Classification - hierarchical structure of the code.

From this base mapping, the WFD water bodies of the rivers, lakes and reservoirs categories were delimited, considering the criteria of drainage area, length and area of the reservoirs. In the various planning cycles, the water bodies were reviewed and had some changes in order to be more adjusted to reality (i.e., construction of new dams).

The new LiDAR survey of Portugal mainland, promoted by DGT, that is planned for 2024, will allow the generation of a new more homogeneous hydrographic network.

4 Conclusions: Benefits for using reference official water data in Copernicus

Need of in situ data for Copernicus Services and validation of satellite-based data products relating to water or hydrology is manifest, and its particular requirements have been continually analysed and identified across the Copernicus. In the library of Copernicus In Situ Component it is possible to find rich and valuable documentation on the matter. As summary there are two main services really connected by water data needs, Land and Emergency monitoring, without losing perspective of Marine and Security services. Most required aspect topics highlighted were identification and delineation of a reliable water network and surface waters, coastline, river level and flow data, and inland water quality and temperature.

Benefits for contributing to Copernicus initiative in water terms is dual, for data providers and Copernicus Services.

National data providers can find a proper way and prime user on Copernicus to put in value their official data, because them will be used for continental assessments, reporting or EU policy affairs. For Copernicus Services make use official national data strengths their capability and helps in the data maintenance without charges for their sides. Sharing data among both contributes is a coordination of public administrations looking for an adjustment of environmental reporting, at national and at continental levels, without bias, because both would use same data origin. Unfortunately, this framework it is not always possible, mainly provoked by technical limitations, no-existence of national data, data license terms and even willingness for both sides. For this reason, it is really needed to work together and make easy the data re-use by Copernicus services.

Acknowledgement:
Delgado, J.[1], Carranza, M.[1], Silvia, M.[2] and Patricio, P.[2]

1 IGN Spain
2 DGT Portugal

Sentinel imagery

Technical specifications, dissemination and future plans

1 Past experience and user requirements

DGT was involved in the first project that was carried out in Portugal for the Sentinel data dissemination, which was the IPSentinel.

The IPSentinel was an infrastructure portal that was used to promote the Sentinel-1, Sentinel-2 and Sentinel-3 data storage and dissemination for the Portuguese territory (Mainland and islands) without any costs. This infrastructure was developed by the DGT in partnership with IPMA (Portuguese Institute for Land and Atmosphere) and funded by a programme of the Directorate-General for Maritime Policy (DGPM) and the European Economic Area Financial Mechanism (EEA Grants).

IPSentinel creation was motivated by the integrated action of the DGT and IPMA in Portugal's policy of active participation in the Copernicus European Earth Observation Programme, namely in its Collaborative Ground Segment (CollGS) program

The project has started in 2015 and ended in 2017 with the implementation of the IPSentinel portal, based on the ESA's Data Hub Software (DHuS), with an obligation to maintain it the until 2022. IPSentinel had a large and frequent number of new registered users, but a low number of active users and product downloads. The main reasons for not using the platform were identified to be the lack of user training for using Sentinel products and possible misleading expectations regarding the available data (users probably looking for value-added or processed products).

***Figure 1**: IPSentinel Logo*

The IPSentinel was passed on to Portugal Space administration in late 2021, and later in April 2023 it closed. It was concluded that Copernicus has a new data access platform: Copernicus Data Space ecosystem, making other platforms, such as "IPSentinel" obsolete, so there is no justification for its continuity.

FPCUP Action 2019-2-31: "Fostering cooperation between Spain and Portugal in the Copernicus land domain"

2 Current stage of Sentinel imagery dataset and their technical specifications

TDGT has been building a solid archive of Sentinel-2 satellite images for the mainland Portuguese territory. The data observation period began in October 2016 and is being discharged every month up to the present. Currently we have almost 7 years of Sentinel-2 data covering a total of 17 tiles.

Images are downloaded from the Theia Land Data Centre, which is a French national inter-agency organization designed to foster the use of images. Theia is supported by 11 French institutions including CNES (Centre National d'Etudes Spatiales). The main reasons for using the Sentinel-2 images from Theia instead of using ESA's databases is their ready-to-use image format and a most accurate and conservative cloud masking.

DGT has also produced a number of derived products from the Sentinel-2 image archive, which are close to the logic of the Analysis Ready Data (ARD). In addition to processing a set of different spectral indices and spectral-temporal metrics for every year, the standout product is the monthly composites of Sentinel-2 images. Monthly composites of Sentinel-2 are created every month, based on the pixel median value of all images in that month, in order to have images without clouds. Linear interpolation by pixel is performed to ensure values without "no data" in the whole image, using images before and after the reference month. The Sentinel-2 monthly composites are used in many applications including machine learning algorithms for deriving LULC products.

Monthly composites mosaics of Sentinel-2 images for Mainland Portugal are made available for the general public throughout a free WMS service. Two colour compositions are made available: True colour and False colour. The data is accessible from the National Geographic Information System (SNIG)[1] portal being available since 31 October 2021. It is also possible to access the mosaics using the viSMOS visualizer, which is a free webSIG platform available in the Portuguese land cover monitoring system SMOS (Sistema de Monitorização da Ocupação do Solo) main internet site. Data can also be provided upon request and a download service is planned for the near future.

1 https://snig.dgterritorio.gov.pt/

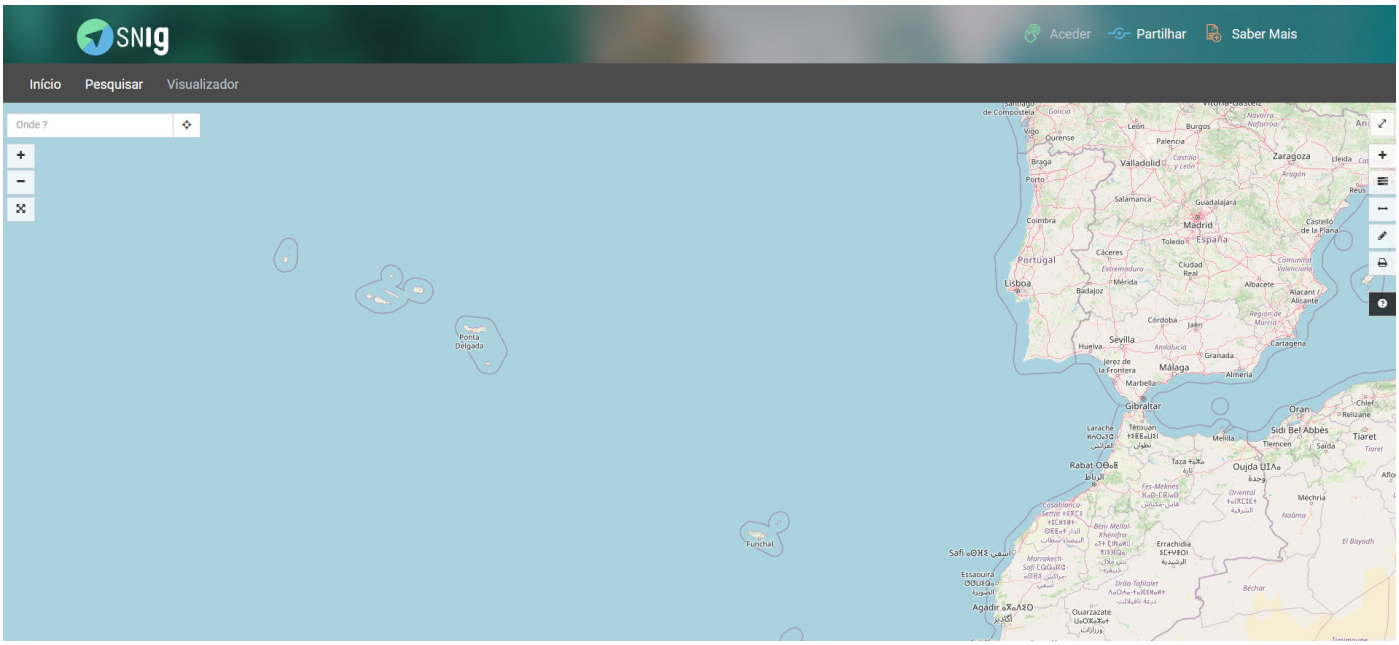


***Figure 2**: SNIG "Visualizador"*

3 Future plans for Remote Sensing and satellite imagery

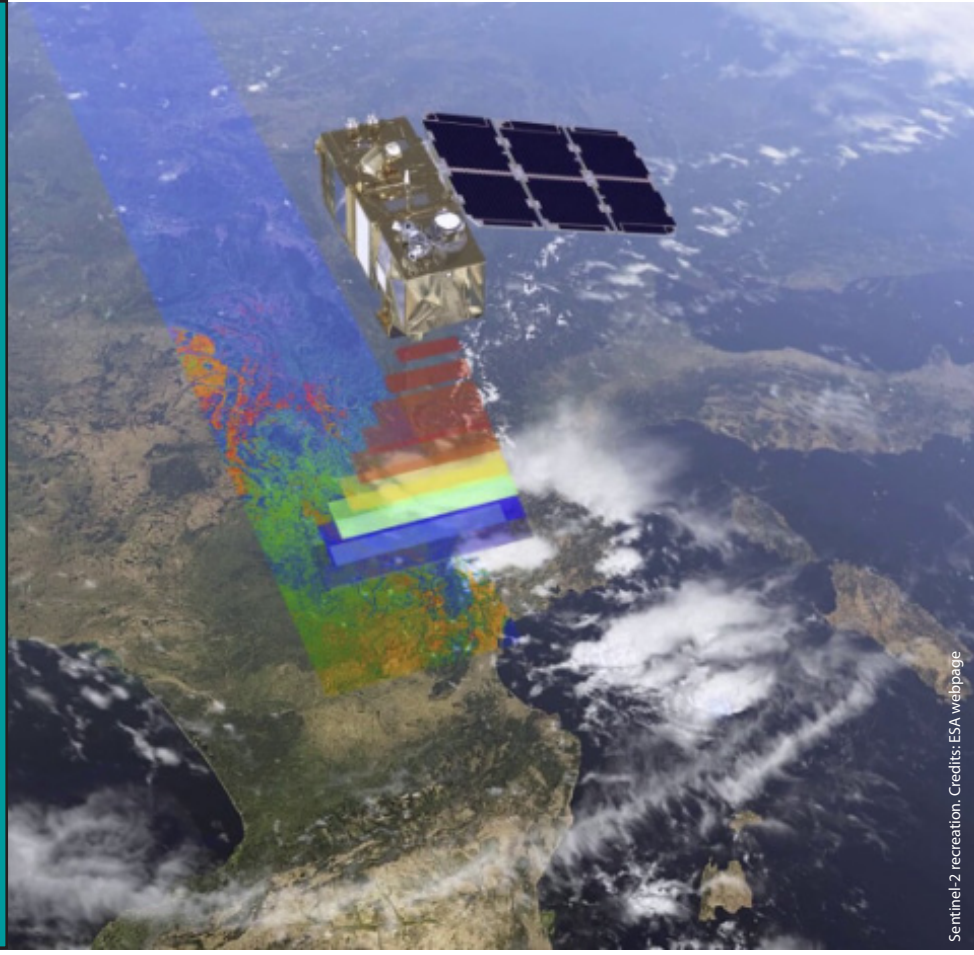
DGT has plans for the acquisition of very high-resolution satellite images (VHRS), higher than the 10-meter resolution observed for the Sentinel-2 data. A tender has been launched to acquire a mainland national coverage of VHRS images with a Ground Sampling Distance (GSD) better than 50 cm on the panchromatic band, with 4 spectral bands (R, G, B and IR) to have similar characteristics as aerial coverage by orthophoto. Two types of products are foreseen, a single pansharpened image acquisition with standard corrections, and a seamless mosaic of pansharpened orthorrectified images. The planned data policy distribution will be made through file and download services creation to DGT and other Public Administration Entities and though the creation of visualization services for the general public. DGT primary use for the VHRS images is to use them as a base map for photointerpretation to produce and update the National Land Cover Land Use official map of mainland Portugal (COS). Other intended uses are to test supervised classification of land cover features, including general improvement of the raster land cover map (Conjuctural COS), monitoring changes in the urban–rural interface, monitoring fuel management bands or landscape transformation programs for fire prevention.

DGT has also plans to acquire super-resolution Sentinel-2 images, with a foreseen 2.5-meter pixel resolution or better. The main uses would be the same as the uses previously pointed out for the VHRS images.

Acknowledgement:
Benevides, P.[1]

1 DGT Portugal

Super-resolution approach with Sentinel 2



1 Introduction

The recent boom in the Artificial Intelligence (AI) field, has opened new paths in R&D in a myriad of disciplines that may profit from this revolution. Certainly, AI as a general concept, has been with us for a while. However, it is right now that is becoming mainstream, and it is foreseen as a catalyst for economic development in the years to come.

The use of AI in conjunction with other techniques as Machine Learning, is used in the Remote Sensing field, trying to overcome some of the inherent limitations of this science. More precisely, to improve the spatial resolution of the satellite products (the so called "super-resolution" technique).

In the past, AI has already been used in Remote Sensing, for example to monitor crops with time series of satellite images.

The aim of this report is twofold:

- Firstly, to summarise the state-of-the-art of AI in Remote Sensing
- Secondly, to present some of the research undertaken by CNIG in the last months, within the FP-CUP action framework, even if there is plenty of room to dig into the subject

2 State-of-the-art, at a glance

We are going to focus here on AI and super-resolution, to improve the spatial resolution in the Sentinel-2 products. From our own research and the feedback from private companies, the ultimate goal would be to obtain a 2,5 meters GSD resolution product by an upscaling of 4x, from the original 10 m offered by Sentinel 2-L2A, bands RGB and NIR (B2,3,4 and 8 respectively). Formerly, works have been mainly focused on increasing the resolution of lower resolution bands (20m. and 60m.)

However, the results obtained are not sufficient to consider it as a valid product in terms of geographic fidelity and/or quality. The problem is that AI in many cases make up the reality, distorting the reality of ground features. Thus, the research is exploring other realistic alternatives, such as a 2x improvement (5m. GSD), instead of 4x.

FPCUP Action 2019-2-31: "Fostering cooperation between Spain and Portugal in the Copernicus land domain"

The general workflow is to use as an input, obviously, the Sentinel-2 product itself, plus a series of very high resolution (VHR) imagery, for AI training and validation purposes. This VHR input should be radiometrically corrected, as well as be contemporary to the S2 product to be "super-resolutioned". Finally, no ground truth would be required with this approach.

After that, the working environment is based on the programming language Python. By using different algorithms, the final product is obtained.

Some of the advantages of this approach for Sentinel-2 are:

- Promotion of the Sentinel products and creation of synergies, with an added value product
- Cost savings versus purchasing VHR imagery
- Expands the potential uses of Sentinel, especially for more detailed enquiries

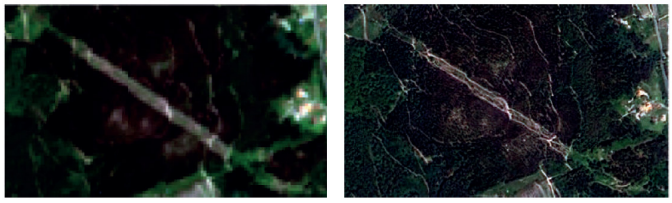


***Figure 1**: On the left, original S2 image, GSD 10m; on the right 8x upscaled S2 product, GSD 1,25. Credits: COTESA leaflet about S2 super-resolution*

3 Research done by CNIG so far, related to FP-CUP goals

As previously told, CNIG has been working in recent years in order to apply already developed artificial intelligence technologies to the cartographic processes. One classic problem in computer vision and image processing is single image super-resolution. The methods already compared are ESRGAN (Enhanced Super-Resolution Generative Adversarial Networks), Real-ESRGAN and HAT (Hybrid Attention Transformer) .

ESRGAN enhanced the visual quality already achieved by the Super-Resolution Generative Adversarial Network (SRGAN) that was able to generate realistic textures but also unpleasant artifacts.

Real-ESRGAN extends ESRGAN to a practical restoration application which is trained with pure synthetic data. This data is synthetized using a second-order degradations process for simulating the complex degradation processes in real images.

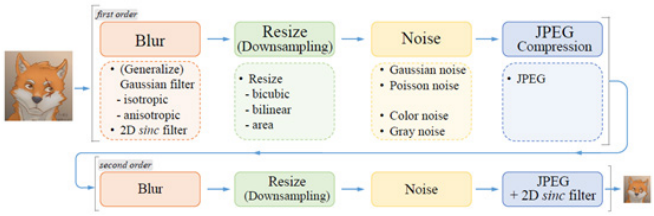


***Figure 2**: Overview of the pure synthetic data generation adopted in Real-ESRGAN. Credits Real-ESRGAN: Training Real-World Blind Super-Resolution with Pure Synthetic Data by Xintao Wang, Liangbin Xie, Chao Dong and Ying Shan.*

HAT is not based on the convolutional neural network but in transformer-based methods that learns context and thus meaning by tracking relationships in sequential data like words in sentence or pixels in an image. They have also uploaded a GAN-based HAT model for Real-World SR (Real_HAT_GAN_SRx4).

First test compares 50 sample areas chosen according to main representations of land use: agricultural land (13 areas), industrial (6 areas), wildlife (13 areas), transportation (6 areas) and residential (12 areas) from Sentinel 2 images. Each 600x600 pixels (6x6 km) area was clipped from Spain National Sentinel 2 Mosaic (L2A). These areas were upscaled using Real-ESRGAN and HAT models twice (5 m/px) and four times (2.5m/px) their original resolution.

Control images were generated for each area downsampling aerial images from the Plan Nacional de Ortofotografía Aérea (PNOA – 25cm/px) to the same resolution.

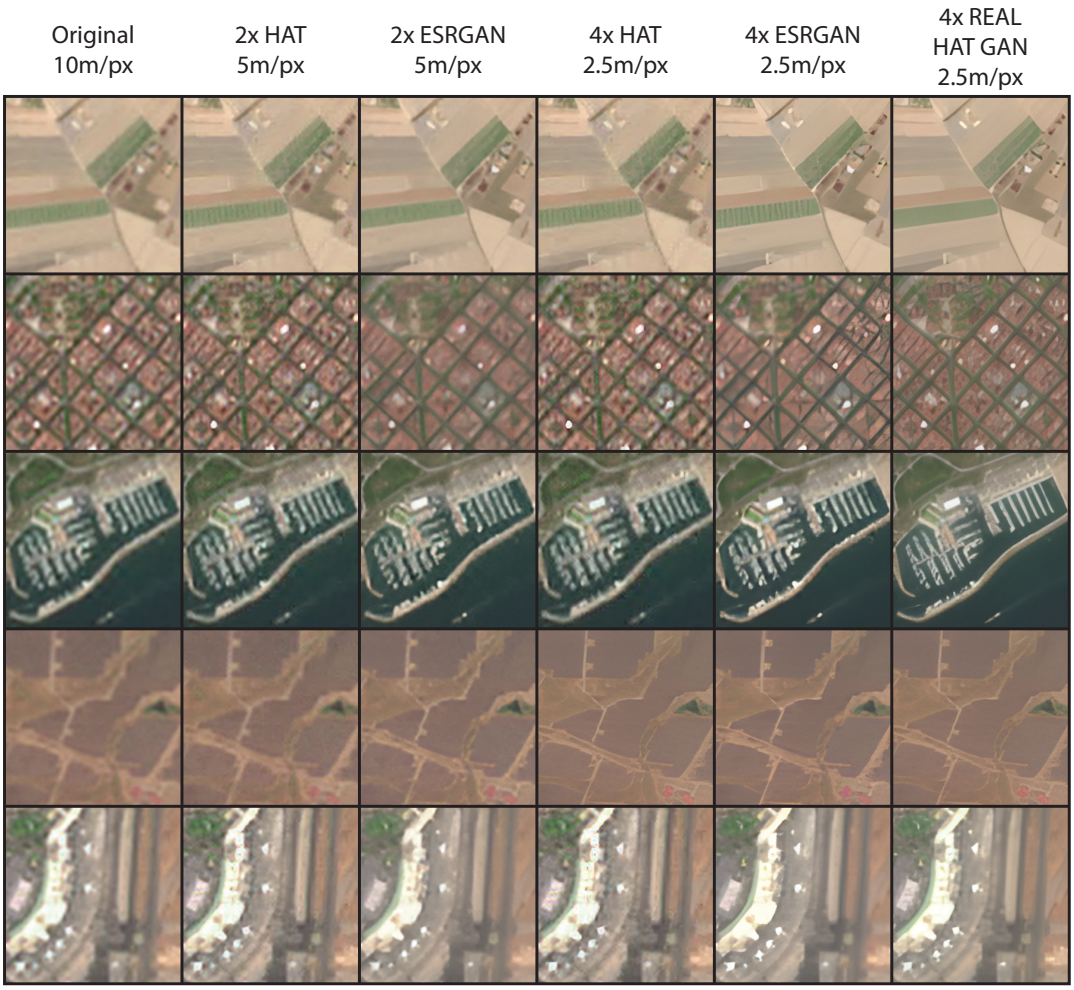


***Figure 4**: Comparative images. agricultural land (Lorca, Murcia), residential (Barcelona), transportation (Gineta, Girona), industrial (photovoltaic power station), transportation (Adolfo Suárez Madrid-Barajas airport).*

As seen in previous images, upscaling using pretrained models from Real-ESRGAN and HAT improves image quality and is able to enhance details. This can be very useful for image interpretation. Higher scales than 2x produce good image textures but are not able to supply the information required for that scale.

Even though results are acceptable, may be possible to improve them by retraining those models with specific images that would fine-tune the models to adapt them to land image textures.

Learning sets will be generated from Geosat-2 and PNOA images.

Product Type	Processing Level and Spatial Resolution			
	L1B (native)	L1S (SR native)	L1C (ortho)	L1D (SR ortho)
Pan-sharpened	1.0 m	50 cm	75 cm	40 cm
Pan	1.0 m	50 cm	75 cm	40 cm
MS	4.0 m	2.0 m	3.0 m	2.0 m
Bundle (Pan+MS)	1.0 m (P), 4.0 m (MS)	50 cm (P), 2.0 m (MS)	75 cm (P), 3.0 m (MS)	40 cm (P), 2.0 m (MS)

***Figure 4**: General specifications for Geosat-2 products. Geosat Imagery User Guide v3.2.*

Training will be done so that higher resolution images improve models for lower resolution images:

Training set		Scale	Upscaled images		
Name	Resolution		Name	Original Resolution	Upscaled resolution
Pansharpened (L1C)	70cm/px	2x →	Sentinel	10m/px	5 m/px
PNOA	25cm/px	2x →	Pansharpened (L1C)	70cm/px	35cm/px

References:
"ESRGAN: Enhanced Super-Resolution Generative Adversarial Networks" by Xintao Wang, Ke Yu, Shixiang Wu, Jinjin Gu, Yihao Liu, Chao Dong, Chen Change Loy, Yu Qiao, Xiaoou Tang.
"Real-ESRGAN: Training Real-World Blind Super-Resolution with Pure Synthetic Data" by Xintao Wang, Liangbin Xie, Chao Dong, Ying Shan.
"Activating More Pixels in Image Super-Resolution Transformer" by Xiangyu Chen, Xintao Wang, Jiantao Zhou, Yu Qiao, Chao Dong.

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1 IGN Spain

Direção-Geral do Território (Portugal)

Instituto Geográfico Nacional (Spain)