ENVIRONMENTAL CRIMES WORKSHOP 2024

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Detecting waste crime with satellite models: From Sentinel-2 to Super-Resolution deep learning for enhanced waste site detection

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EMERITUS project

emeritus

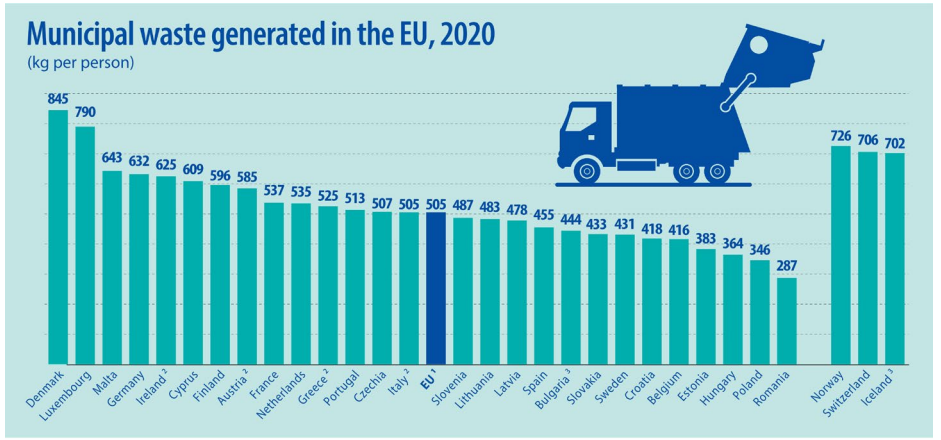
Eviron**ME**ntal c**RI**mes' in**T**elligence and investigation protocol based on m**U**itiple data **S**ources

EMERITUS is an innovation project aimed at supporting Law Enforcement Authorities (LEA) and Border Guards (BG) in the investigation and evidence collection against waste-related environmental crimes. To this end, the project will offer a combined package of digital tools, including a single-entry point platform integrating advanced technologies, a training package, operative and train-the-trainers oriented, and an investigation protocol to guide LEAs and BGs in the integration of digital technologies in their daily operations.

Challenges of waste management

Continuous growth of global population and its behaviour when it comes to socio-economic practices set the premise for a lot of environmental crimes. Illegal deposits and dump sites are the results of those practices. Globally, by 2040 there will be around 3.4 billion tons of waste. (Kaza, 2018).

In Romania stricter EU regulations and imports of waste created an environment prone to multiplication of ***illegal waste dumps.***



Captură Facebook / Octavian Berceanu

Use cases: identification of illegal waste in Romania and Greece

Involved partners:

Romanian Border Police

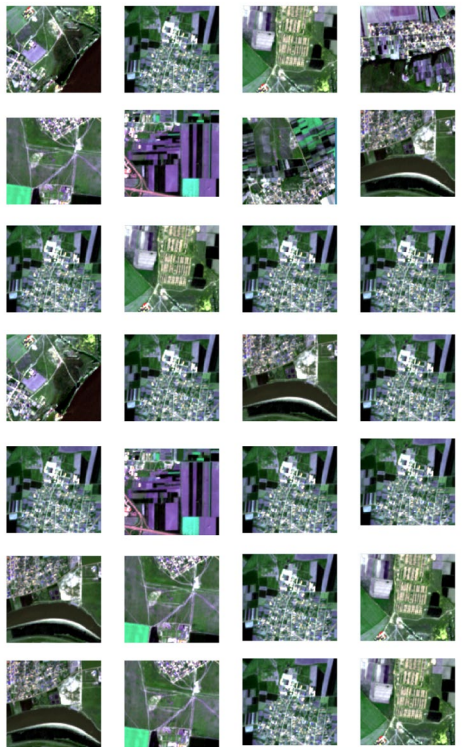
Romanian National Environmental Guard

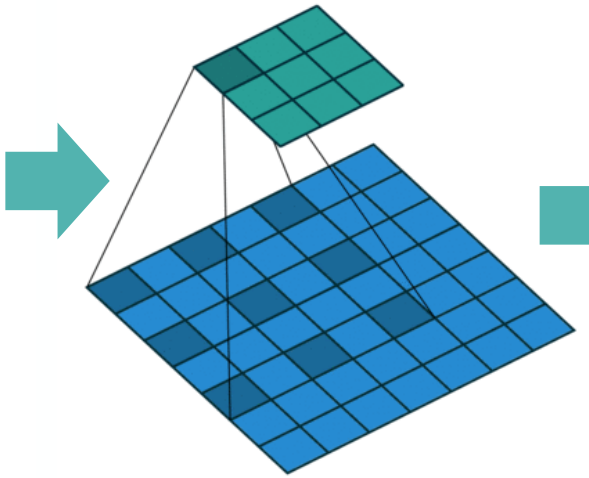
Moldovian Police

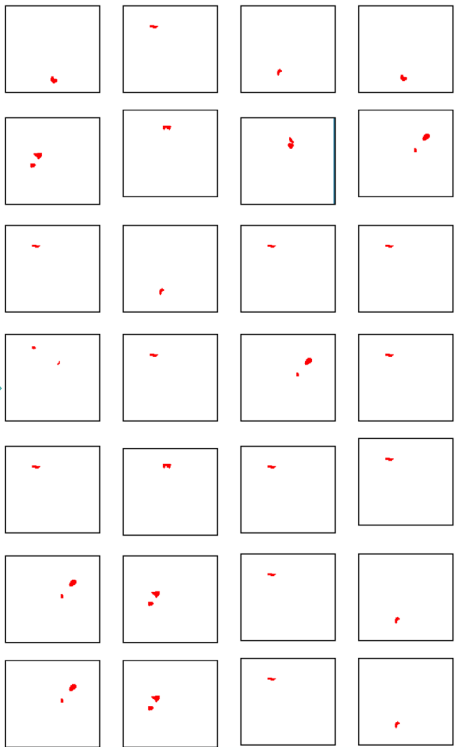
Moldovian Inspectorate for Environmental Protection

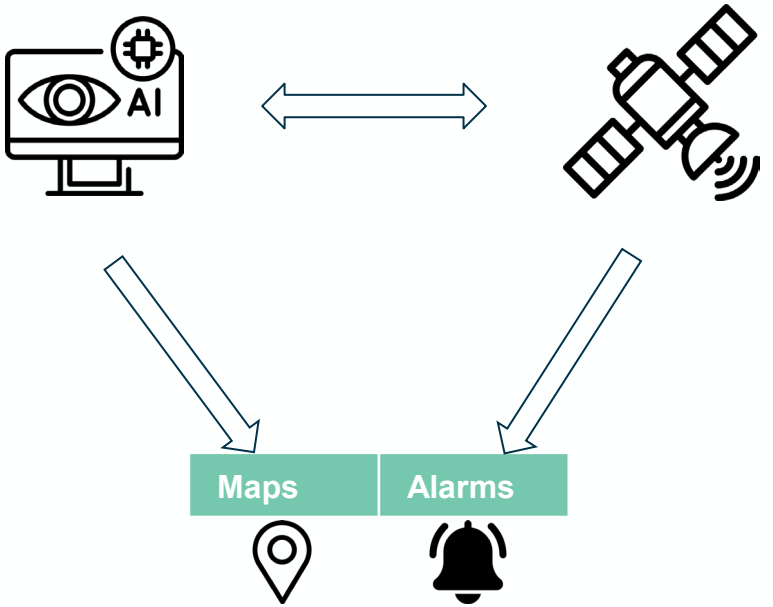
GMV Romania

Proposed Solutions - GMV Models



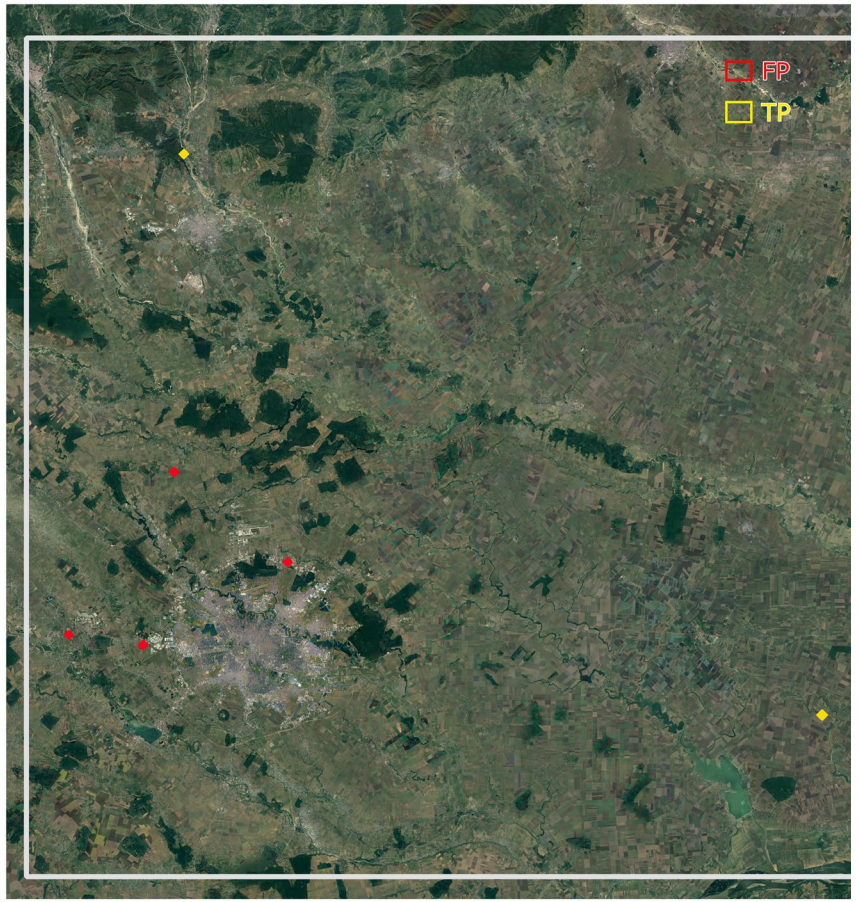




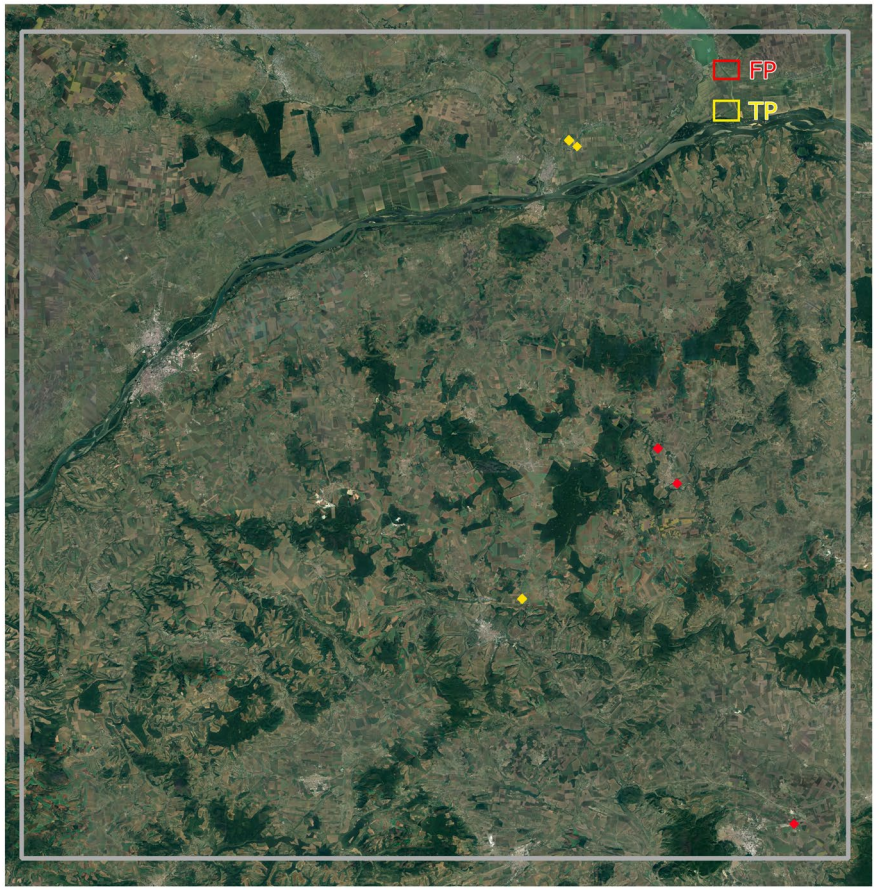


Deep Learning on Sentinel 2 tiles results

T35TMK, 29/07/2020, DeepLabV3+ & ResNeSt101



T35TMJ, 23/08/2021, DeepLabV3+ & ResNeSt101



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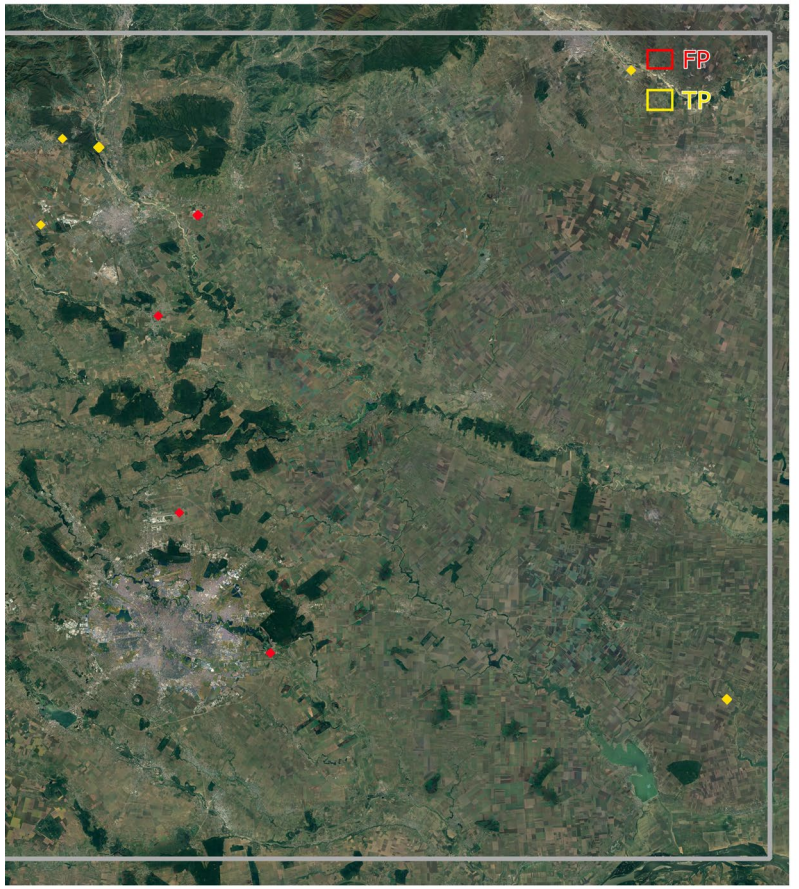
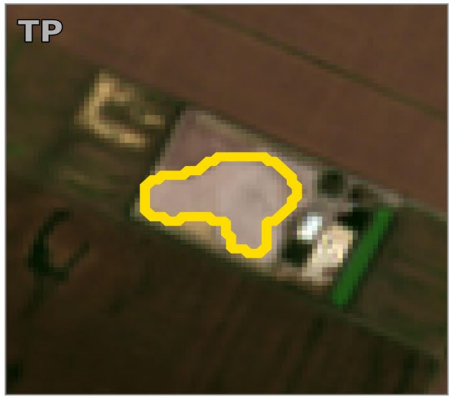
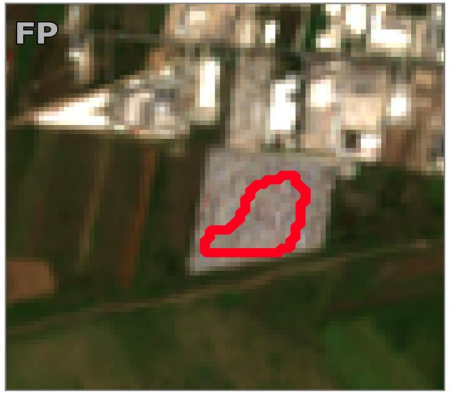


True Positives and False Positives Insights 1

T35TMK, 23/08/2021, DeepLabV3+ & ResNeSt101

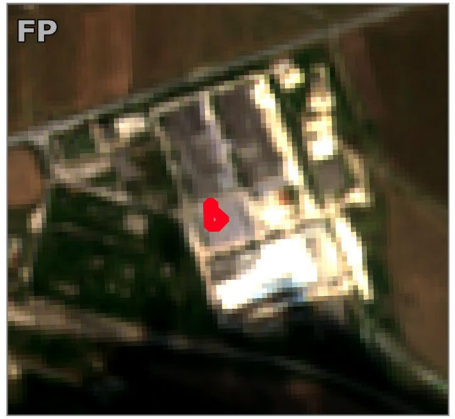
T35TMK, 29/07/2020, DeepLabV3+ & ResNeSt101

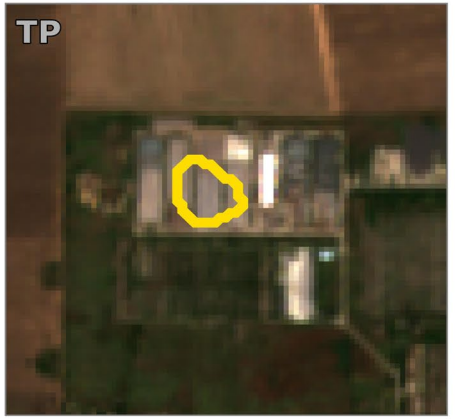


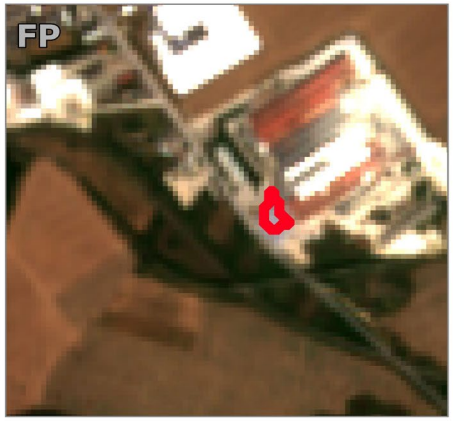


True Positives and False Positives Insights 2

T35TMJ, 23/08/2021, DeepLabV3+ & ResNeSt101







T34TFS, 26/06/2019, DeepLabV3+ & ResNeSt101

T35TNL, 28/08/2020, DeepLabV3+ & ResNeSt101

Models metrics

Model + Encoder	Bands	v_Precision	v_Recall	v_IOU	t_Precision	t_Recall	t_IOU
DeepLabV3+ & ResNeSt 101e	**02, 03, 04, 08, 11, 12**	**0.73**	**0.82**	**0.63**	**0.67**	**0.75**	**0.54**
DeepLabV3+ & ResNeSt 200e	02, 03, 04, 08, 11, 12	0.75	0.78	0.62	0.59	0.76	0.50
DeepLabV3+ & SeResNeXt 101 32x4d	02, 03, 04, 08, 11, 12	0.8	0.67	0.57	0.86	0.43	0.40
Manet & SeResNeXt 101 32x4d	02, 03, 04, 08, 11, 12	0.77	0.67	0.55	0.64	0.69	0.49
DeepLabV3+ & ResNeSt 101e	02, 03, 04, 05, 8A, 12	0.75	0.73	0.59	0.67	0.65	0.49

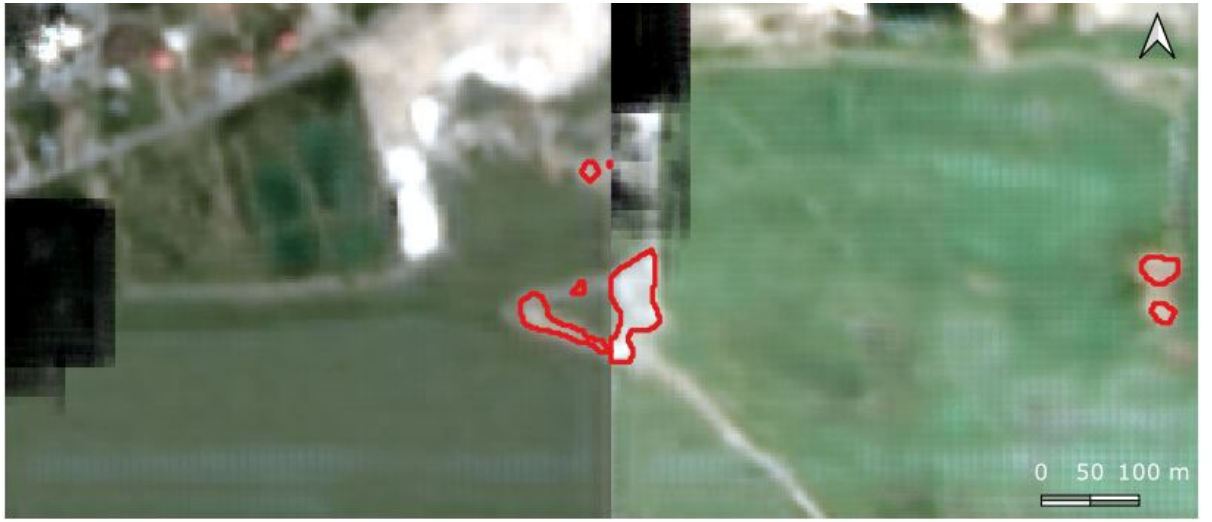
Super-resolution approaches for waste identification

SRCNN

SRResNet

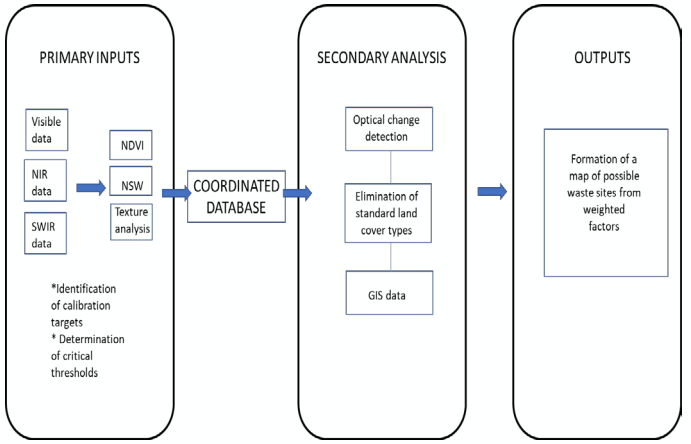
EDSR

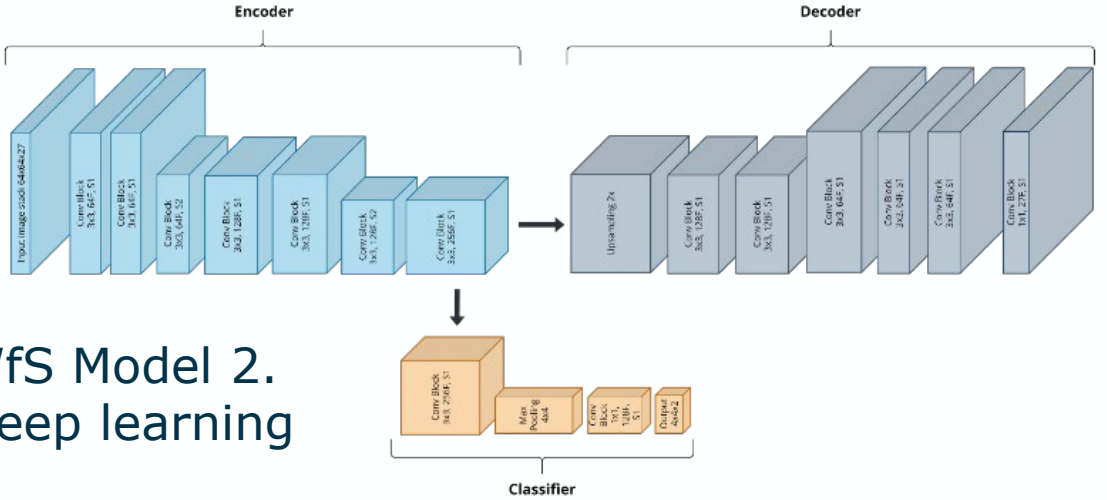
RRDB



Proposed Solutions - ASE Models

WfS Model 1. Semi-automated (original)





WfS Model 2. Deep learning

Models 1 and 2 use Sentinel satellite data, which is free, and enables us to examine large areas to detect potential waste sites, eventually at country scale. We use Sentinel data at a first stage to detect potential waste sites and then to examine these sites in detail using very high resolution images.

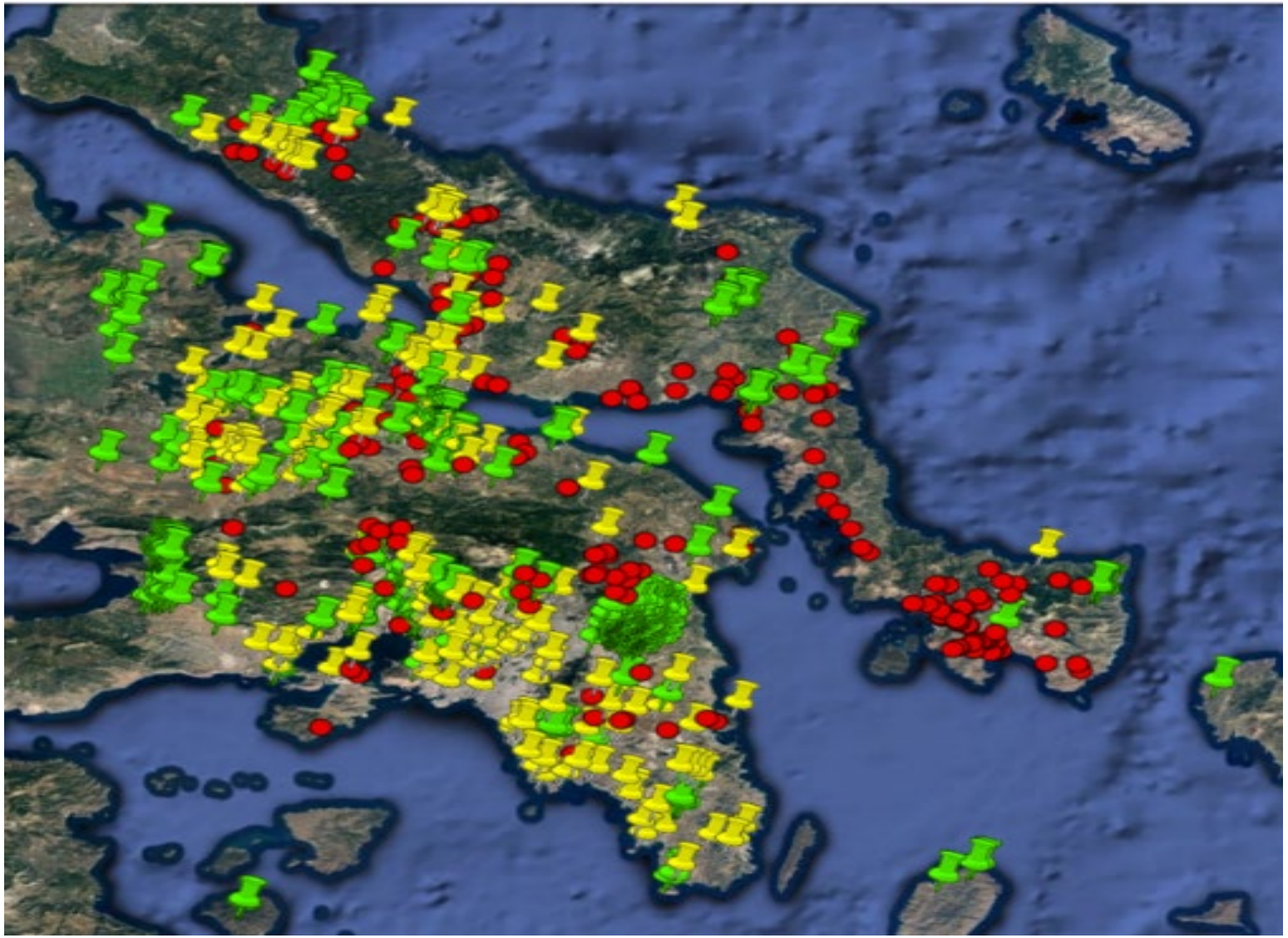
Model 3. Hotspots (fires)

Sentinel 2 tiles results from ASE models in Greece Athens region

Red dots - detection model 1

Yellow pins - detection model 2

Green pins – hotspots model 3



Results and validation

Confirmed waste sites

About 55-70% of site locations we give to environmental protection authorities are found to be unlawful waste sites after site visits.

Sites that were previously unknown

The Hellenic Police were not previously aware of 46% of the unlawful waste sites that they first visited.

The Ministry for the Environment, New Zealand found that 59% of the targets were previously unknown to them.

Good intelligence finds

The Hellenic Police said' that 34% of the sites from the total data given were 'very useful intelligence'.

In New Zealand 26% of the sites from the total data given were 'very good intelligence finds'.

So low-cost data but high value intelligence.

Results and validation(category 1 are sites that are most likely to be unlawful, category 4 are least likely to be unlawful)

WfS Model 1

Category 1 sites (59 cases)

Category 2 sites (38 cases)

Category 3 sites (48 cases)

Category 4 sites (54 cases)

WfS Model 2

Category 1 sites (20 cases) – 12 after duplicates with other models

Category 2 sites (37 cases)

Category 3 sites (32 cases)

Category 4 sites (114 cases)

Model 3 Hotspots

Category 1 sites (5 cases)

* 76 sites given to the Hellenic Police to investigate on the ground.

Similar works at GMV - EOLAW project

EOLAW was based on virtual platform technology to develop novel services based on EO data combined with ICT data analytics and non-EO data for the Law Enforcement sector

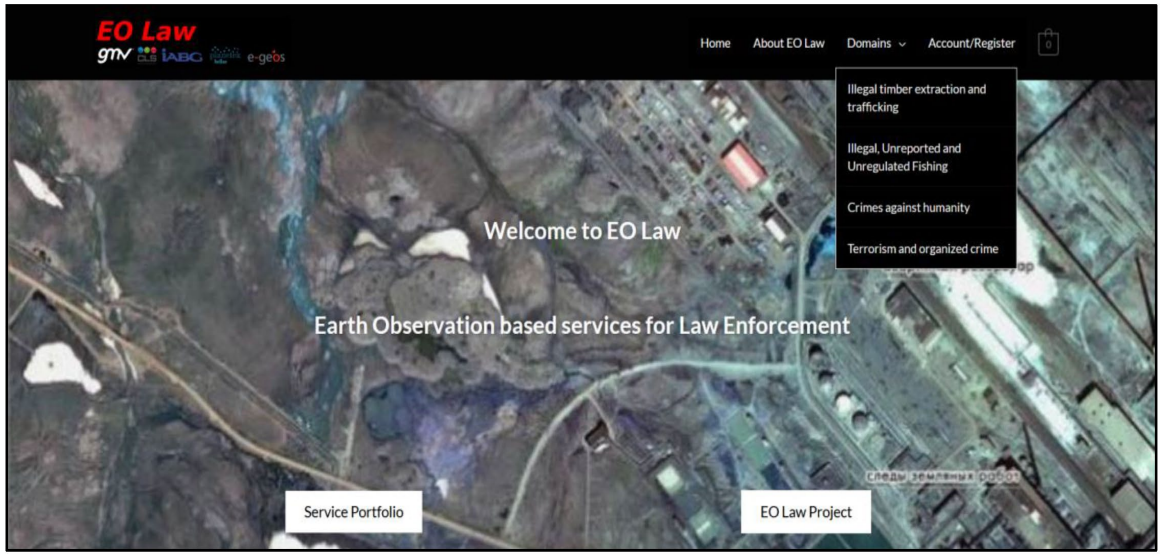
Objectives

-Demonstrate impact and benefit from an integrated approach combining multiple datasets and analyses for stakeholders in the Law Enforcement domain

-Increase awareness, acceptance and understanding of the potential benefits in the Law Enforcement domain of using EO derived information

-Test prototype capabilities as a possible basis for future operational implementation

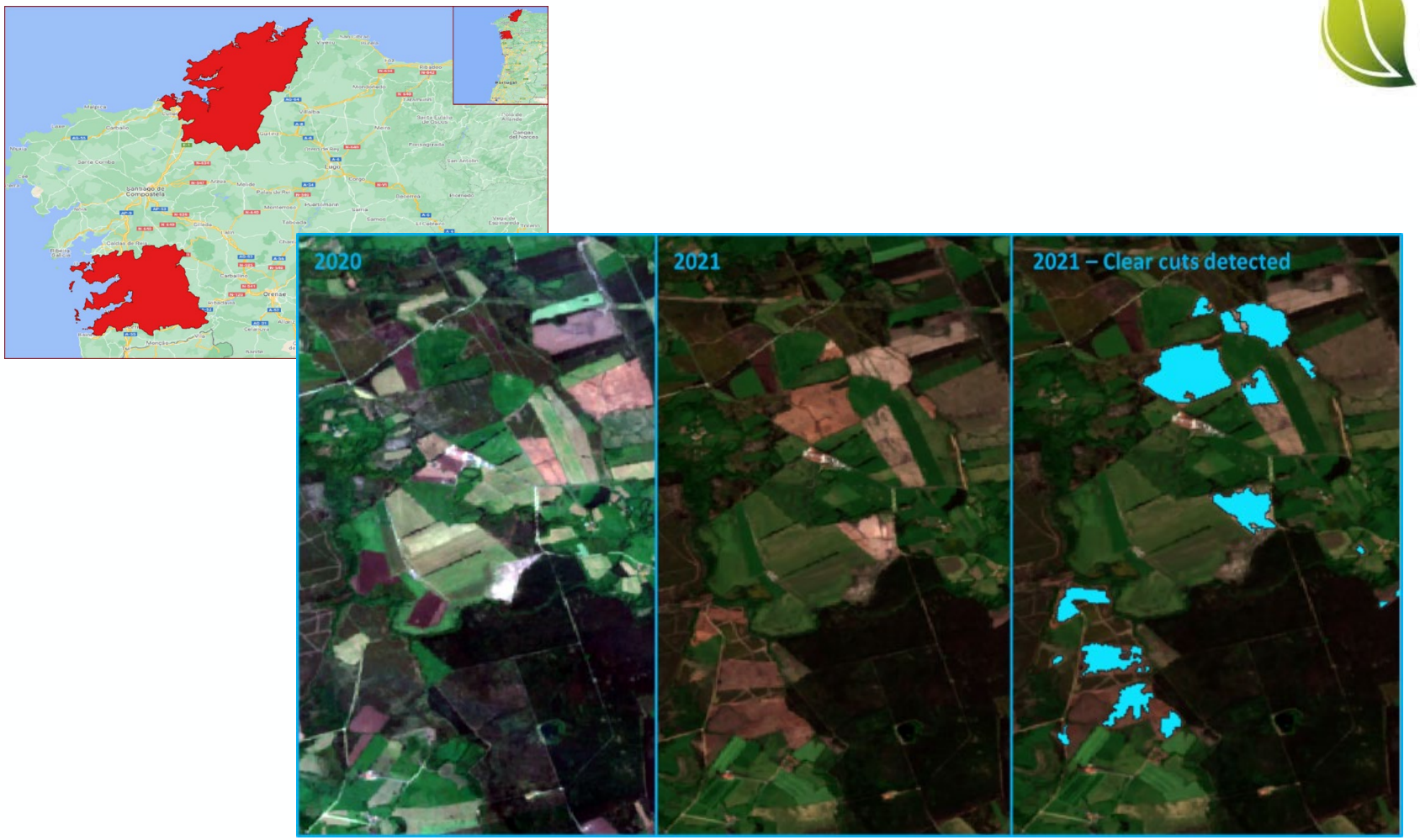
-Enable flexible access to EO derived information and analytic capabilities compliant with standards, formats and practices



Users : Interpol, Europol (observer), International Criminal Court, Indian Ocean Commission (Regional Maritime Information Fusion Centre), Forest Stewardship Council certification, ENCE, Xunta de Galicia, World Uyghurs Congress, Federal Criminal Police Office of Germany (Observer), Austrian Ministry of Interior (Observer)

Environmental crimes – Illegal timber extraction and trafficking

DETECTION AND MONITORING OF FOREST CHANGE



Added value for the stakeholders:

- Large areas being continuously analysed for the presence of clear cuts
- Various formats of outputs customized for different use cases
- Identify suspicious activities that could be further investigated (e.g., route characterization, logging machinery, etc.)