Monitoring and fighting environmental crimes with VHR satellite imagery

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I. Environmental Hazard Detection

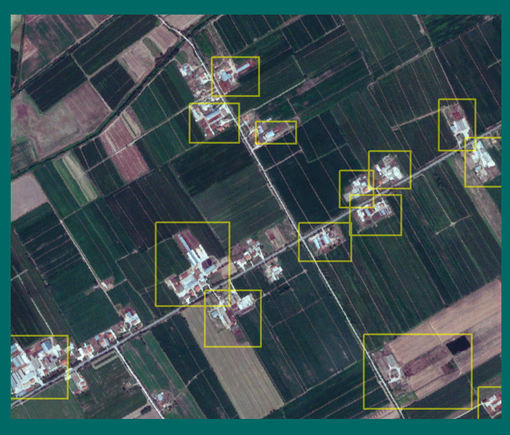
Illegal waste management and spills in surface waters are significant environmental issues in both industrialized and developing countries. These phenomena require the detection of pollution sources or polluted sites to make public authorities fully aware of the necessary actions for the prosecution of criminal actions and the restoration of the environment.

Detection of potential polluted sites (micro-dumps) obtained through the analysis of VHR satellite images.

Case study: Province of Caserta, Italy

Detection of potential pollution sources (cattle-breeding facilities) near waterways in VHR satellite images.

Case study: Agnena river, Province of Caserta, Italy

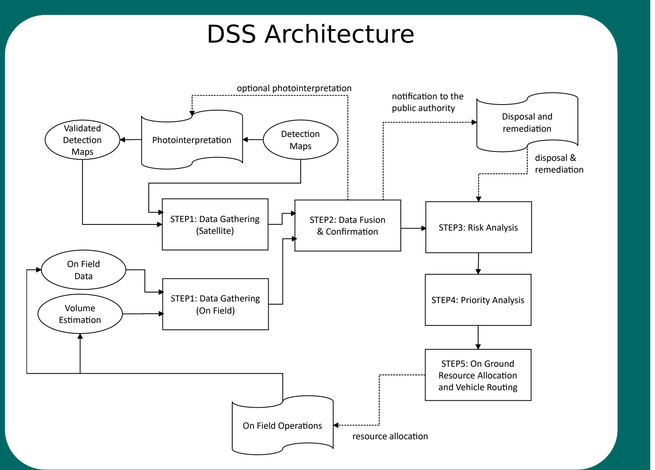


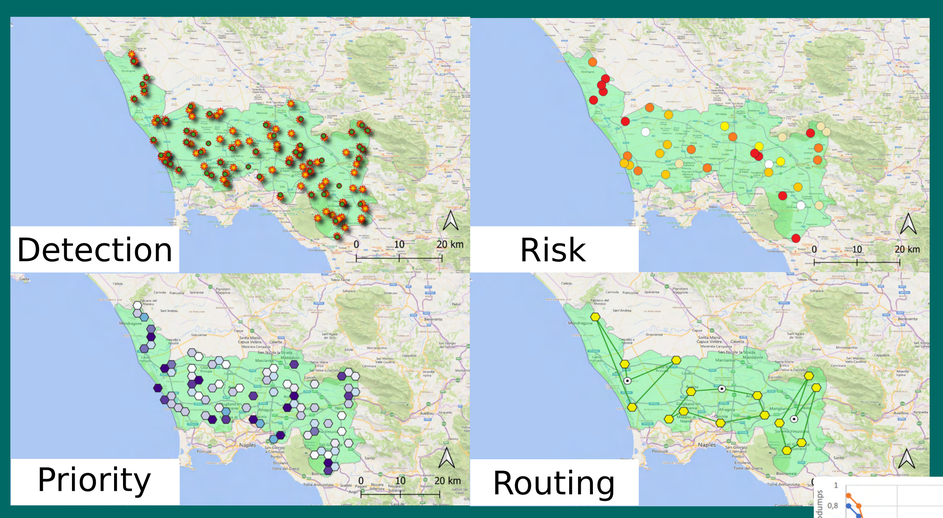
III.Decision Support System

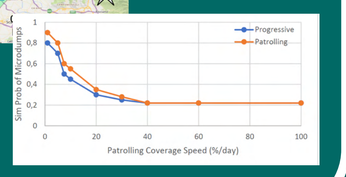
DSS based on progressive monitoring aims to support public decision makers in illegal dumps monitoring and in the prioritization of field operations based on the available resources.

Monitoring process steps:
STEP1: insert information from various data sources into the system with different reliability and descriptive completeness
STEP2: consolidate information
STEP3: evaluate the environmental risk
STEP4: Prioritize areas to visit for confirmation and characterization
STEP5: allocate resources on the territory

DSS Architecture







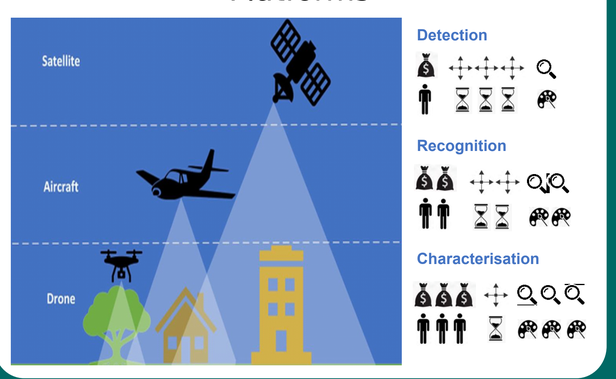
The design of the monitoring system can be performed after a cost-benefit analysis.

II.Progressive monitoring

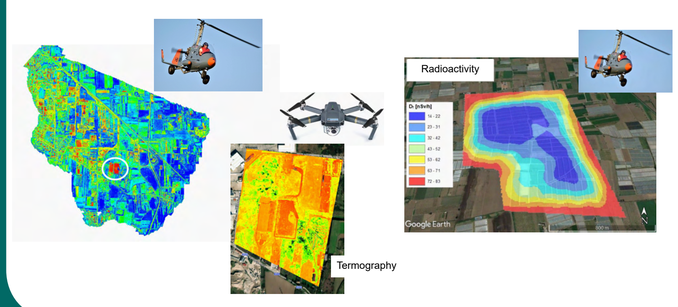
The concept of "progressive monitoring" defines various stages of the monitoring process, each one suitable to be implemented with a specific platform (satellite, aerial, close range) to be integrated, toghether with on-ground surveys, in a Decision Support System (DSS).

In particular, satellite VHR images are employed to generate (unvalidated) micro-dump detection maps for subsequent validation by photo-interpreters.
The detection is based on machine learning and deep learning techniques.

Platforms



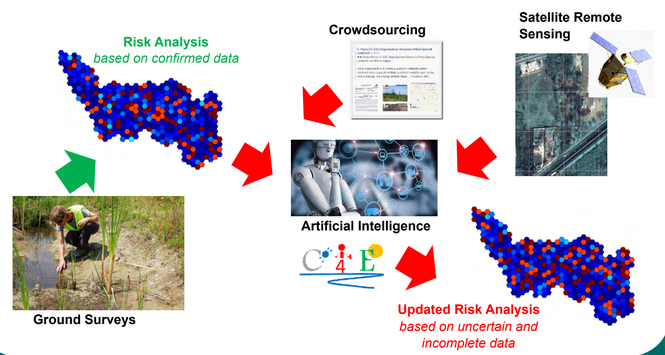
Detailed analysis



When needed a detailed analysis is performed with low altitude platforms which guarantee the signal acquisition with a finer ground resolution.

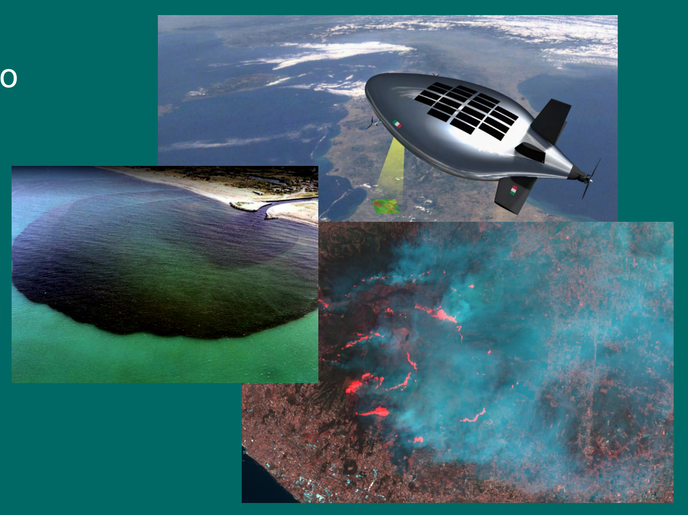
Data fusion allows the integration of ground survey data with remote sensing data for updated estimation of environmental risk maps.

Data Fusion



IV.Towards persistent monitoring

HAPSs (High Altitude Pseudo Satellites) represent a new era for Earth Observation since they allows a continuous monitoring thanks to the station keeping feature and a good compromise in terms of spatial resolution *vs* area coverage.



To face this challenge, CIRA is developing a research program on an Hybrid Stratospheric LTA platform that will allow the detection of environmental criticalities, also of short duration, in real time.

Selected References

M. Lega, D. Ceglie, G. Persechino, C. Ferrara and R. M. A. Napoli, "Remote sensing in environmental police investigations: aerial platforms and an innovative application of thermography to detect several illegal activities", Environmental Monitoring Assessessment, 2014.

A. Errico, C.V. Angelino, L. Cicala, G. Persechino et al. "Detection of environmental hazards through the feature-based fusion of optical and SAR data: a case study in southern Italy," Int. J. Remote Sensing, vol. 36, no. 13, 2015.

F. Gargiulo, C.V. Angelino, L. Cicala, G. Persechino and M. Lega, "Remote Sensing In The Fight Against Environmental Crimes: the Case Study of the Cattle Breading Facilities in southern Italy ", WIT International Journal of Sustainable Development and Planning, 2016.

S. Parrilli, L. Cicala, C. V. Angelino, and D. Amitrano, "Illegal Micro-Dumps Monitoring: Pollution Sources and Targets Detection in Satellite Images with the Scattering Transform", IEEE IGARSS, 2021.

V.R. Baraniello, G. Persechino, F.Tufano, C.V.Angelino, "The application of high altitude pseudo-satellites for a rapid disaster response", IEEE IGARSS, 2021

G.. Buzzo, G. Gigante, F. Nebula, R. Palumbo, D. Pascarella, and A. Vozella, "Risk Assessment for Illegal Waste Open Burning", E3S Web of Conferences, 2021.

F. Nebula, F. Gargiulo, G. Gigante, D. Pascarella, and L. Cicala, "Multiple-tour constrained optimization for waste sites inspections," in International Conference on Optimization and Learning (OLA), 2021.

D. Amitrano, L. Cicala, G. Cuciniello, M. De Mizio, M. Poderico, and F. Tufano, "Near Real-Time Volumetric Estimates Using Unmanned Aerial Platforms Equipped with Depth and Tracking Sensors", MDPI Sensors, 2022.

L. Cicala, F. Gargiulo, S. Parrilli, D. Amitrano, G. Pigliasco, "Progressive monitoring of micro-dumps: a case study over the Campania Region (Italy)", SPIE Remote Sensing, 2023.

M. Gargiulo, C. Savarese, F. Tufano, S. Parrilli, M. De Mizio et al., "Assessing the Impact of Soil Contamination on Maize Plant Development using UAV-Based Multispectral Indices", ICUASS 2023.

C. Marrocco, A. Bria, F. Tortorella, S. Parrilli, L .Cicala, M. Focereta, G. Meoli, M. Molinara, "Illegal Microdumps Detection in Multi-Mission Satellite Images with Deep Neural Network and Transfer Learning Approach", IEEE Access 2024.