Remote Sensing Tools for Environmental Innovation

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I.RE.TE.TH.

Environmental Innovation

Environmental Innovation (market, industry)

* Environmental innovations are

- **organizational implementations and changes focusing on the environment**,
- **with implications for companies' products, manufacturing processes and marketing, with different degrees of novelty**.

1. They can be merely incremental improvements that intensify the performance of something that already exists, or
2. radical ones that promote something completely unprecedented, where the main objective is to reduce the company's environmental impacts.

In addition, **environmental innovation** has a bilateral relationship with the level of **proactive environmental management adopted by companies.**

* Fernanda Dias Angelo, Charbel Jose Chiappetta Jabbour, Simone Vasconcellos Galina, (2012) "Environmental innovation: in search of a meaning", World Journal of Entrepreneurship, Management and Sustainable Development, Vol. 8 Iss: 2/3, pp.113 - 121

# Environmental Innovation (EU & citizen)

- Any form of innovation aiming at significant and demonstrable progress towards the goal of **sustainable development**.
- This can be achieved either **by reducing the environmental impact** or achieving **a more efficient and responsible use of resources**.

ECO-Innovation Action Plan, European Commission, Environment

- The term "environmental innovation" is used in similar contexts to "eco-innovation"
- It is the development of products and processes that contribute to **sustainable development, applying the commercial application of knowledge to elicit direct or indirect ecological improvements**.
- This includes a range of related ideas, from environmentally friendly technological advances to socially acceptable innovative paths towards sustainability.
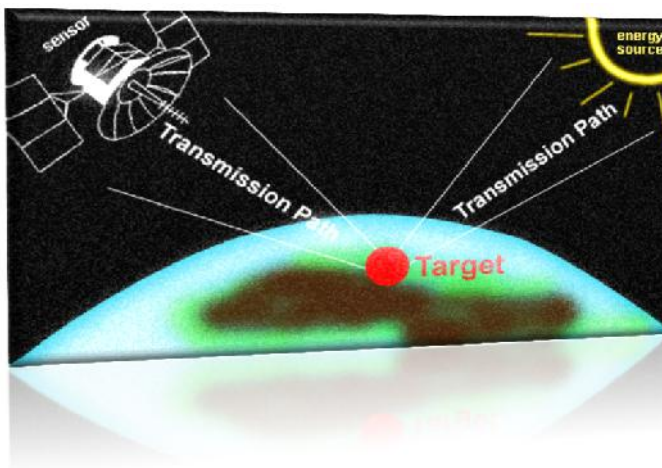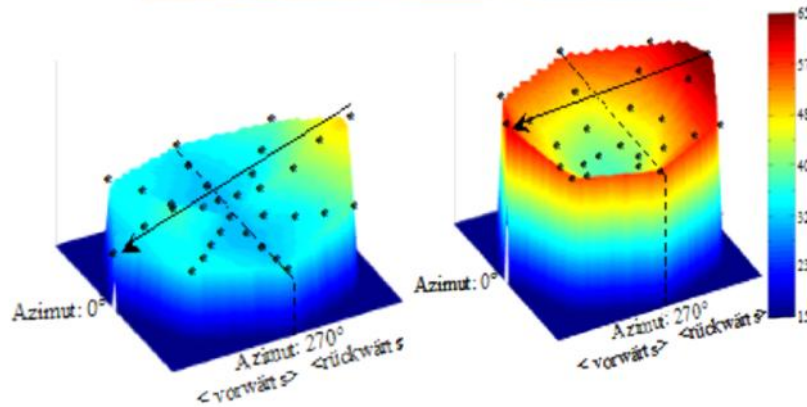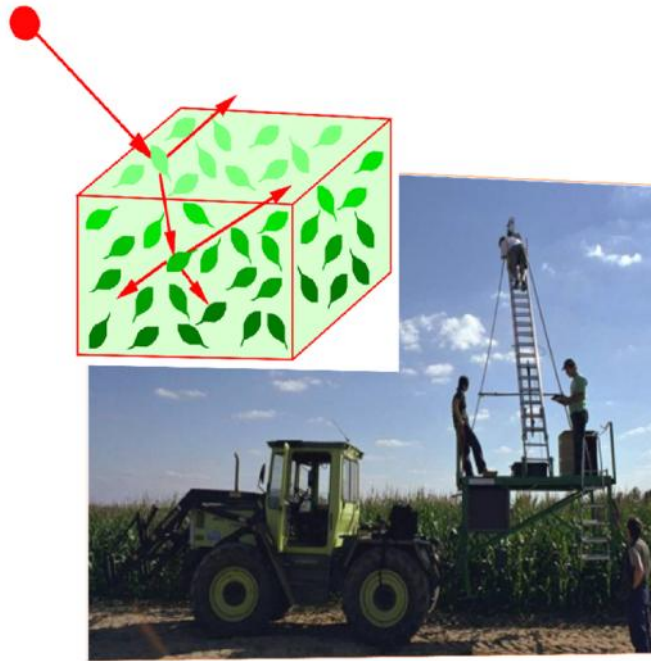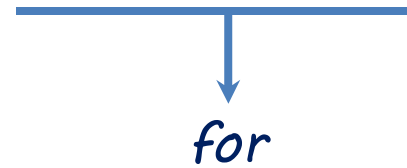
Remote Sensing Tools

Remote Sensing Tools (technology)

Platforms

Sensors

Methods

Tools

(Products & Services)
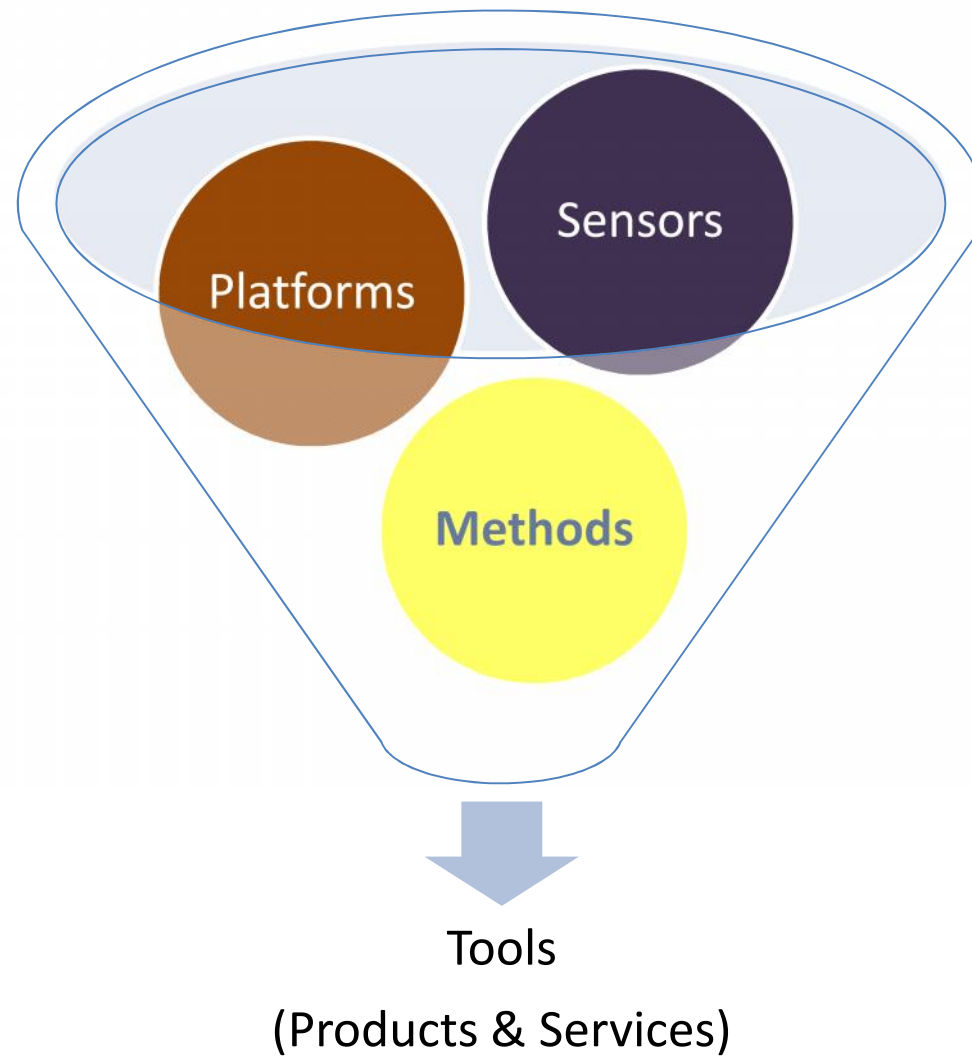
Remote Sensing Tools (products & application sectors)

Maps
Models' input parameters
Scenaria validation

for

Earth Sciences
Life Sciences
Security
Energy
Environment
Climate Change
Food Security
Capacity Building
other sectors ….

Remote Sensing Tools (land cover information)

What may be delivered by or with the support of the "eye from the sky":

- Land cover, land use information

- Land cover changes, time series analysis, actual status in relation with existing management maps & plans

- Inland water bodies distribution, connectivity, status

- Landscape formations and natural surface structures (rocks and faults, peaks and valleys)

Remote Sensing Tools (land features information)
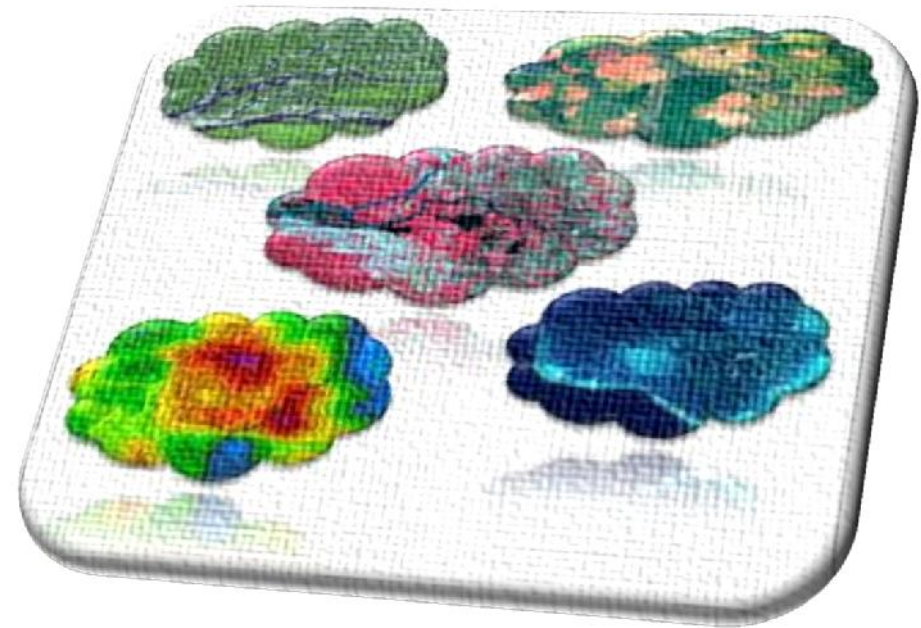
What may be delivered by or with the support of the "eye from the sky":

- Vegetation cover extent

- Delineation of adequate cultivation zones for productive plants

- Status of the vegetation cover and yield estimation

- Rock, soil features and pattern recognition

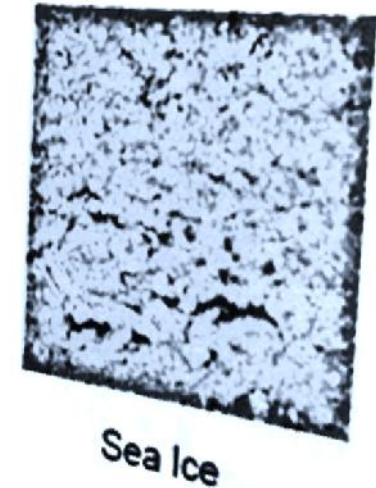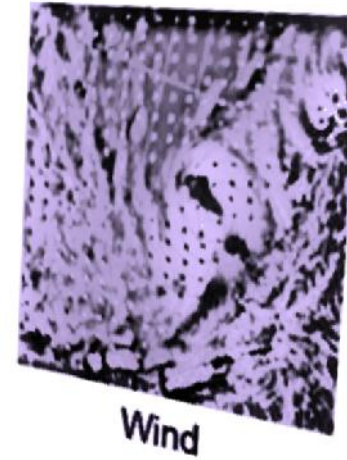- Surface humidity and evapotranspiration regime

Evapotranspiration in the Nile Delta

Remote Sensing Tools (sea features information)
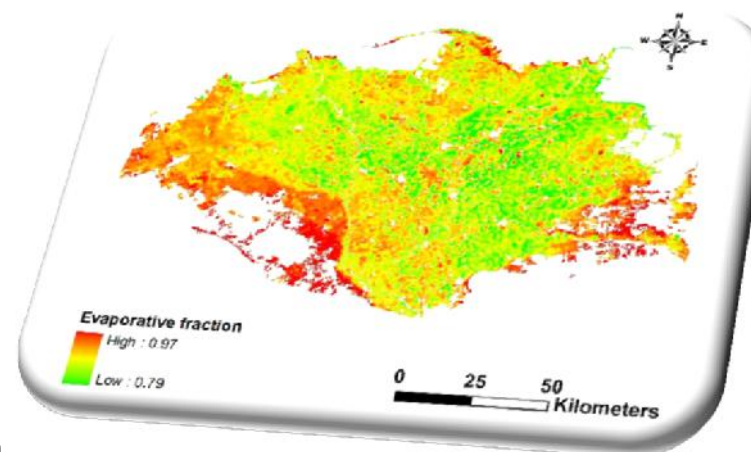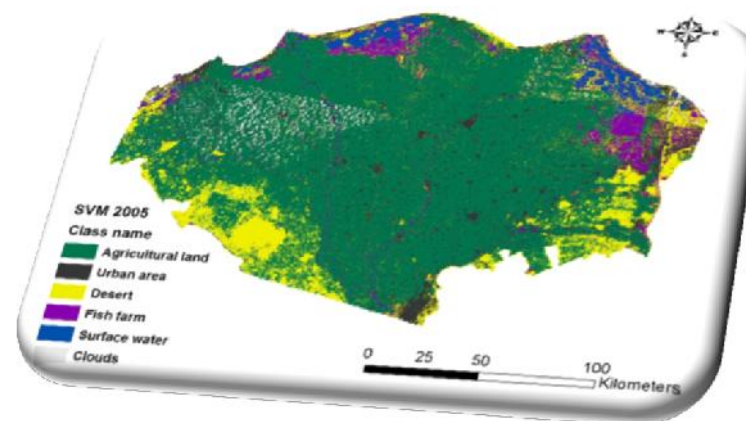
What may be delivered by or with the support of the "eye from the sky":

- Sea wave heights' maps

- Time Series maps

- Prevention and Monitoring of disastrous events

- Best route design

- **+ atmosphere features information: e.g. Weather – Atmosphere condition information, Registration of sudden extreme events, etc.**

Wind

Sea Ice

Sea State

Land-Water Line

Remote Sensing Tools (advantages)

Coverage

Timeliness

Repeatability

Objectivity

Availability

Price

Decision value

CERTH acknowledges international developments

Framework conditions
CERTH acknowledges international developments

Trends

Various resolutions

Different sensors

Diverse classification schemes

Multi-modal & -source data

Process automation

Web downstream services

Tailor made solutions

Pan-European layers

Variables for earth system monitoring

Free data policy

Assets or Issues

- Multiple applications
- International coordination
- Product validation
- Mission continuity

- Engagement of member states
- Research
- Standardization, Harmonization

- INSPIRE Directive: Key step to ensure compatibility among spatial data infrastructures
- CORINE Land Cover

Operational European mapping and monitoring services

CERTH acknowledges international developments

CORINE Land Cover & Land Cover
Change products - EEA

CLC for 1990, 2000, 2006
CLC2012 under production
39 EU countries currently involved
Comparable nomenclature, MMU
Enhanced semi-automatic mapping
Accuracy ≥85% for CLC & CLCC

GMES Initial Operation Land
Pan – European layers (2011 – 2014)

- Pan-European global component
(biophysical variables) (EU JRC)
- Pan-European LC, LCC, and LC
characteristics (EEA)
- Local high resolution information on
specific areas of interest (EEA)
- In-situ data, including access to a reference
data building on INSPIRE architecture and
useful for several Copernicus services (EEA)

European Urban Atlas

Pan-European LULC data for Large Urban Zones
Urban Atlas for 2006, 2012
Urban Atlas 2012: 695 Large Urban Zones | EU28 cities with population > 50,000 | 17 urban classes (MMU 0.25 ha), 10 rural (1 ha)

European Forest Monitoring

JRC European Forest Data Centre products
GMES Service Element Forest Monitoring
Sentinel-2 expected to boost forest monitoring

Credits: ESA
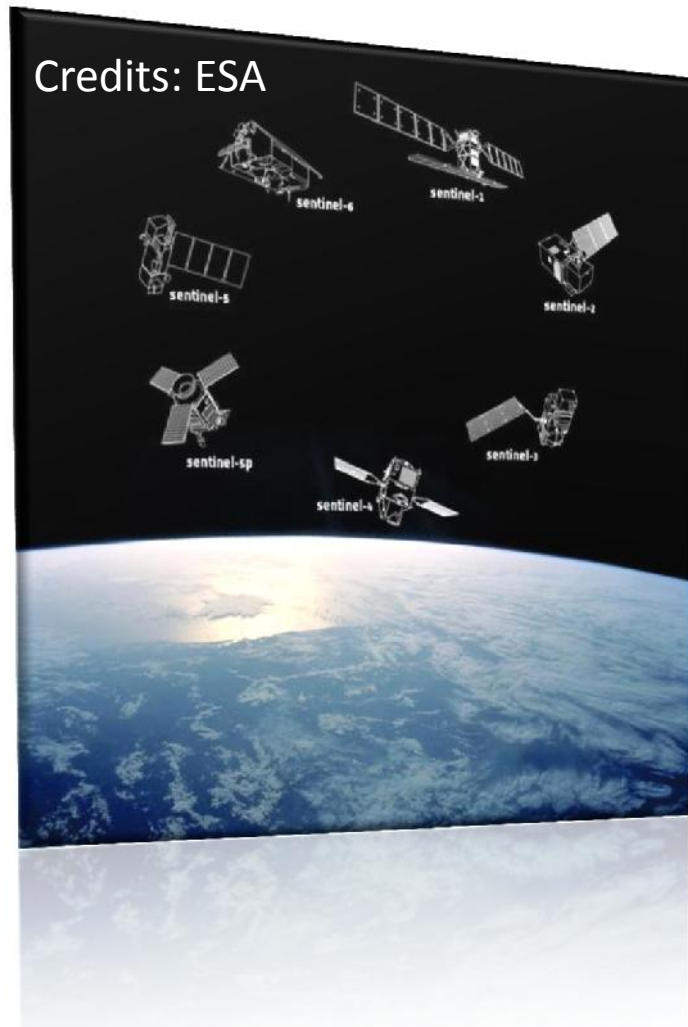
Sentinel 1 – SAR imaging - All weather, day/night applications, interferometry x 2 satellites, 693 km, Dawn dusk orbit

Sentinel 2 – Multi-spectral imaging - Land applications: urban, forest, agriculture,..
Continuity of Landsat, SPOT x 2 satellites, 786 km, LTDN 10:30 am

Sentinel 3 – Ocean and global land monitoring Wide-swath ocean color, vegetation, sea/land surface temperature, altimetry
x 2 satellites, 814 km, LTDN 10:00 am

Sentinel 4 – Geostationary atmospheric - Atmospheric composition monitoring, trans- boundary pollution

Sentinel 5 – Low-orbit atmospheric, Atmospheric composition monitoring
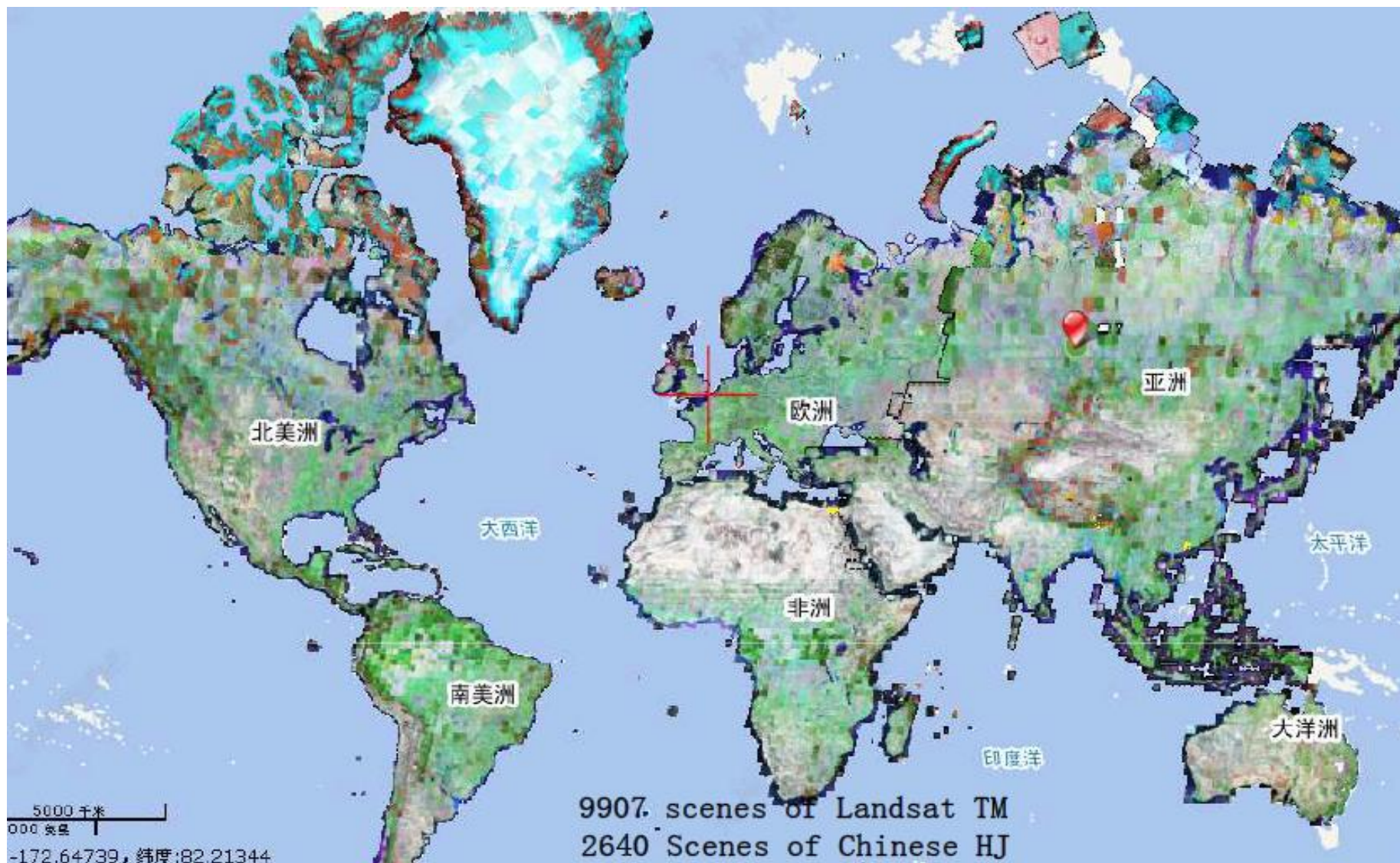
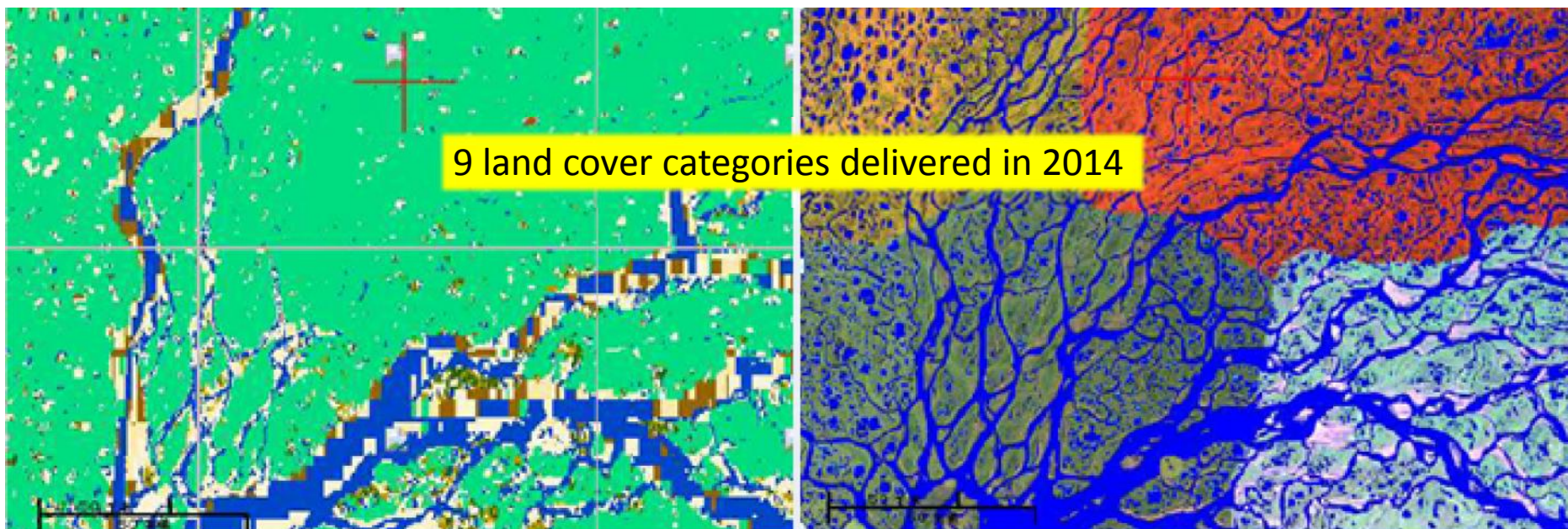# Operational global mapping and monitoring services
CERTH acknowledges international developments

[Credit: Prof Chen Jun, ISPRS Chairman, Director of the National Geomatics Center of China, Leader of the GEO Task SB-02 C1]

9907 scenes of Landsat TM
2640 Scenes of Chinese HJ

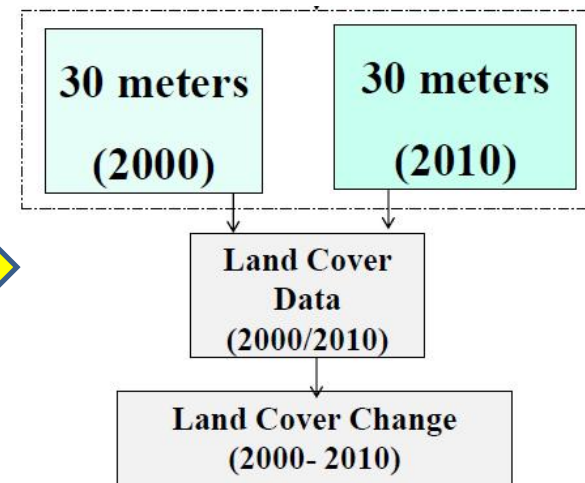# *Operational global mapping and monitoring services*
CERTH acknowledges international developments

[Credit: Prof Chen Jun, ISPRS Chairman, Director of the National Geomatics Center of China, Leader of the GEO Task SB-02 C1]

No	Products	Spatial Resolu.
1	USGS	1km
2	UMD	1km
3	BU	1km
4	GLC2000	300m
5	GLOBCO VER	300m
6	Japan	250m

Inland Water mapped to

30 meters (2000)

30 meters (2010)

Land Cover Data (2000/2010)

Land Cover Change (2000- 2010)

9 land cover categories delivered in 2014

classification methods

- Hyperspectral data:

    Support and Relevance Vector Machines highly effective and robust

- VHR data:

    classifiers using both spatial + spectral information

- Trends in automatic classification:

    semi-supervised learning, active learning, and domain adaptation in case of limited training samples

- Optical–SAR synergies:

    Random Forests efficient in combining multi-sensor data

- VHR Optical:

    Object-oriented rule-based classifier using spectral, spatial, and texture features

State of the art mapping methods
CERTH acknowledges international developments

change detection

- Algebra methods:
  Image differencing, ratioing, regression, change vector analysis

- Transformation-based:
  PCA, Iteratively-Reweighted Multivariate Alteration Detection, curvelets

- Classification-based:
  Post-classification comparison, Multi-temporal Spectral Mixture Analysis

- Time series analysis:
  Trajectory analysis, Time series segmentation

National practice examples
CERTH acknowledges international developments

➢ **Land Information System Austria (LISA)**

• Objective: Achieve consensus on LC base, apply cutting-edge science, & provide cost-efficiency
• Object-Orientated Data Model, LC & LU distinct data models, 13 LC & 6 LU classes, accuracy 95.5% LC, 88% LU, 97% change/no change
• LISA represents the minimum requirements of local, provincial, and federal authorities

➢ **Digital Land Cover Model for Germany (DLM-DE)**

• Motivation: Requirement of higher resolution LC maps than the CLC, high consistency, data reuse
• RapidEye & DMC data, existing ATKIS data
• Products for years 2006, 2009, 2012, 2015, 2018

National practice examples
CERTH acknowledges international developments

> **LC/LU in United Kingdom**

- UK national LC products: 1990 (LCMGB), 2000 (LCM2000), 2007 (LCM2007)
- Landsat data, from pixel- (1990) to object-based (2000, 2007) classification, 80–90% accuracy
- Next UK LCM will be closely integrated with Copernicus LMCS

> **LC/LU in the Netherlands**

- Four databases related to LC at national scale
- LGN6 database (2007/2008): 39 classes, Landsat & IRS-P6 data, Accuracy ~85% for crops
- Independent of CLC, harmonization is not straightforward

> **LC/LU mapping in Eastern European Countries**

- FAO Land Cover Classification System taxonomy
- Countries: **Albania, Azerbaijan, Bulgaria, Moldova, Romania**
- Mainly Landsat data
- Result harmonization will be required, might be overcome by the wide adoption of LCCS

➢ **Crop type and grassland mapping**

•Objective: Identification of trends and threats on agricultural production

•Multi-scale analysis of seasonal time series data, NDVI, seasonality indices, OA 86% (5 classes)

•HR-MR data combination proved efficient – SAR data promising alternatives

➢ **Assessment of Mediterranean areas prone to land degradation**

•Low resolution AVHRR data, Spectral mixture analysis

•Green Vegetation Fraction index linearly correlated with vegetation cover in warm areas

➤ Biophysical variable extraction

• Inversion of radiative transfer models (e.g. PROSAIL) to retrieve vegetation properties
• Ratio & orthogonal vegetation indices, mainly from red & NIR bands
• Retrievable properties: Chlorophyll, Nitrogen, fAPAR, Leaf Area Index, Canopy water

➤ Changes in Ecosystem Services

• Relating provisioning and regulating ESS with land transformations
• Landsat time series, spectral mixture analysis, linear regression modelling
• Spider diagram for visualization

➤ Carbon stock estimation for REDD+ (Reducing emissions from deforestation and forest degradation)

• RS derived Above Ground Biomass as proxy
• X-, C-, and L-band SAR & RapidEye data, Matched Filtering for AGB estimation
• TerraSAR-X & RapidEye using multiple MF fractions the most accurate results

Scientific tools & databases
CERTH acknowledges international developments

BioMA software portal | eHabitat| Agri4Cast - ImageServer| Digital Observatory for Protected Areas (DOPA) | Environmental Marine Information System | European Alien Species Information Network | European Forest Fire Information System - current situation map |European Soil Data Centre - Maps | Farm Advisory System | Flood forecasts - European Flood Alerting System | Forest Cover Maps |Fraction of Absorbed Photosynthetically Active Radiation | Global Burnt Area 2000-2007 | Global Disaster Alert and Coordination System | Global Flood Detection System| Global Land Cover (GLC2000) |iMAP |JRC water portal | Map viewer European Drought Observatory Map viewer - European Soil Data Centre Map | Radiation Transfer Model Intercomparison | Soil data and information |Tree species habitat suitability map - under climate change | World Atlas of Desertification …..
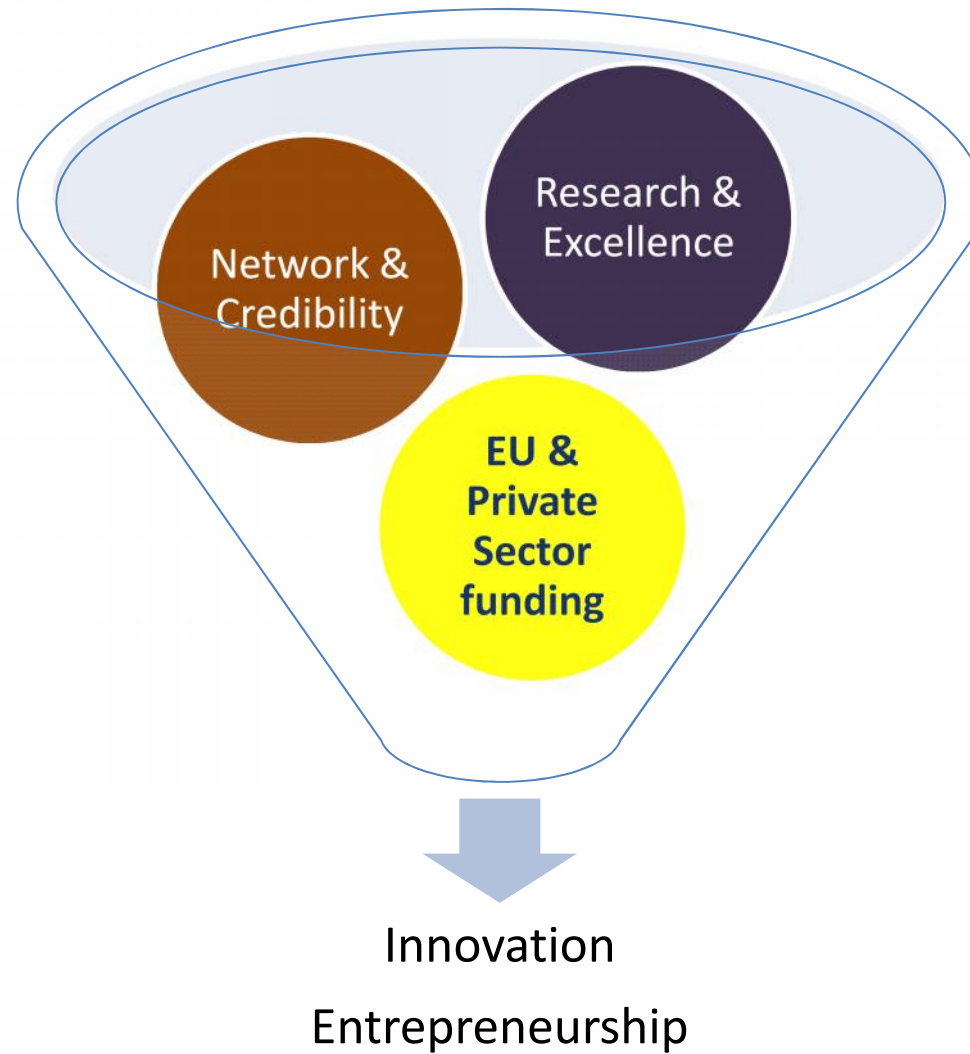
CERTH participates in international developments

Innovation

Entrepreneurship

CERTH participates in international developments
Network & Credibility

Remote Sensing and Digital Image Processing

Manakos · Braun Eds.

Ioannis Manakos
Matthias Braun *Editors*

Land Use and Land Cover Mapping in Europe

Practices & Trends

Land Use and Land Cover Mapping in Europe

EARSeL

Springer

Published: 2014
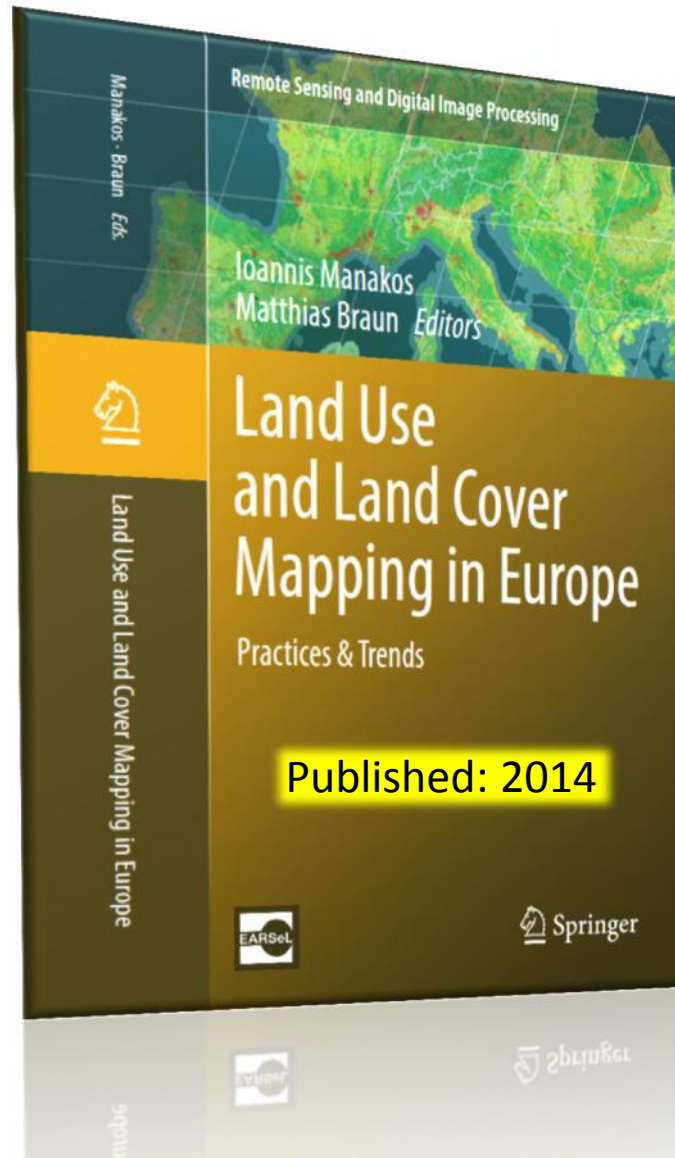
First joint Workshop of the EARSeL
Special Interest Group on Land Use & Land
Cover and the NASA LCLUC Program on
**"Frontiers in Earth Observation for
Land System Science"**

March 2014

EARSeL

NASA LCLUC
Land-Cover / Land-Use Change
Program

GEO GROUP ON
EARTH OBSERVATIONS

esa

AutoGiG   From Space to Place

Earth Observation data analysis for habitat and biodiversity monitoring

- Harmonization of the Land Cover Classification System (LCCS) with the General Habitat Categories

- Habitat mapping

    - Use of Dempster–Shafer theory

        - to handle uncertainty in expert rules

        - to handle missing data – allowing multiple classes

    - Use of fuzzy logic

        - To handle noise afflicted data

        - To handle inaccurate expert rule

- Estimation of vegetation height through 2D texture analysis as a surrogate for LIDAR

- Extraction of biodiversity indicators & change detection

Multi-sensor early warning systems: FIRESENSE (Fire Detection and Management

through a Multi-Sensor Network for the Protection of Cultural Heritage Areas from the

Risk of Fire and Extreme Weather Conditions, FP7-ENV-2009-1–244088-FIRESENSE)

- Research on:
    - Fire/smoke detection from optical and IR cameras,
    - Fusion of information from additional sensors (e.g. wireless temperature sensors)
    - Fire propagation estimation using vegetation and fuel modeling from satellite images.

- Tested in Greece, Turkey, Italy and Tunisia.
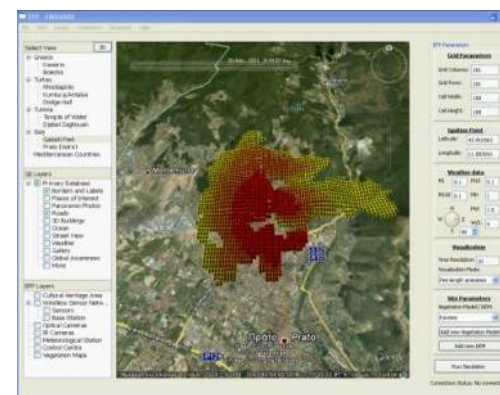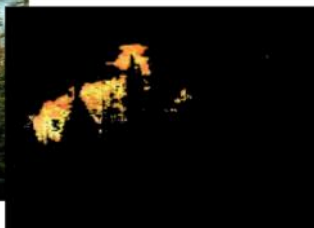
Tools for education and training of Fire volunteers (including vegetation mapping)

Open protocols and tools for the edUcation and Training of voLuntary organisations in the field of Civil Protection, against nAtural Disasters (forest fires) in Greece and Bulgaria

(INTERREG IV OUTLAND, European Territorial Cooperation Programme Greece-Bulgaria 2007-2013)
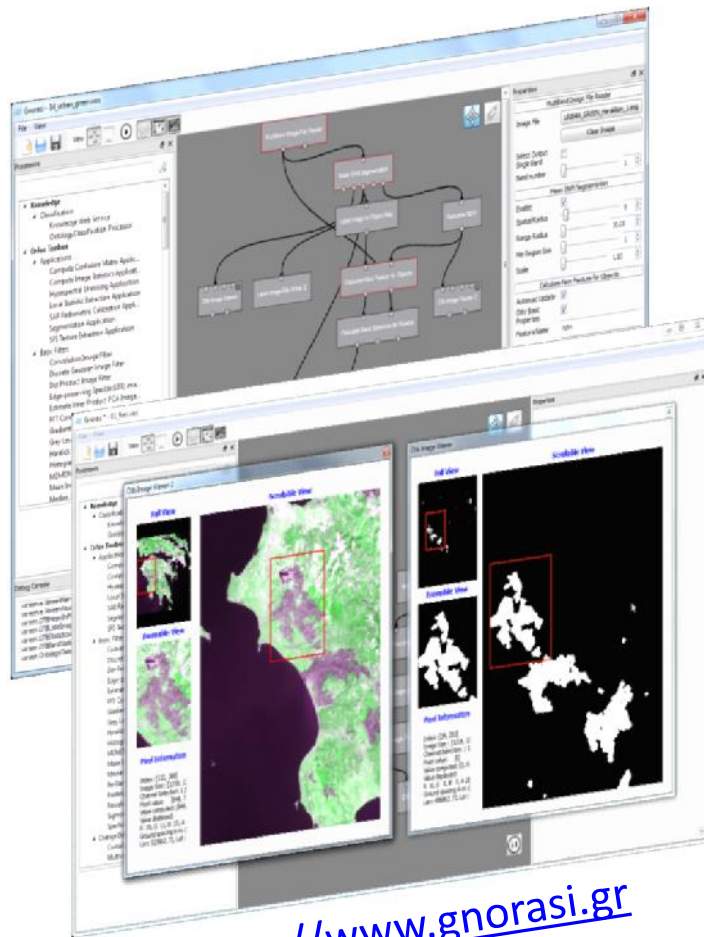
- Development of an interactive platform for the operational support and training of Volunteer Groups of Civil Protection Services.
- Uses Mobile (Android) and Web technologies, Fire Simulations and Shortest path routing calculation.
- The system can also be used for collaborative vegetation mapping of areas (crowd-sourcing) and can be extended for other applications.

http://www.gnorasi.gr

GNORASI : Knowledge and processing algorithms for remote sensing data

An Open Source Integrated Information System for Automation and Systematic Interpretation of Remotely Sensed Data

- Knowledge-based object classification using ontologies and fuzzy reasoning

- Preprocessing tools for efficient noise and distortion removal, data transformation and full georeferencing.

- Visual and data enhancement tools, including digital filters, color compositing, pansharpening and others.

- Supervised classification techniques.

- Principal Components Analysis.

- Segment-based classification whereby pixels are grouped into segments based on homogenous spectral similarity.

- Support for creating and editing different types of use case scenarios such as: Burnt/Flooded Area Detection, Urban Green Spaces, Leakage Recognition and contamination in aquatic systems, Detection of urban sprawl, Agricultural crop types

CERTH participates in international developments
Research, Excellence & EU funding
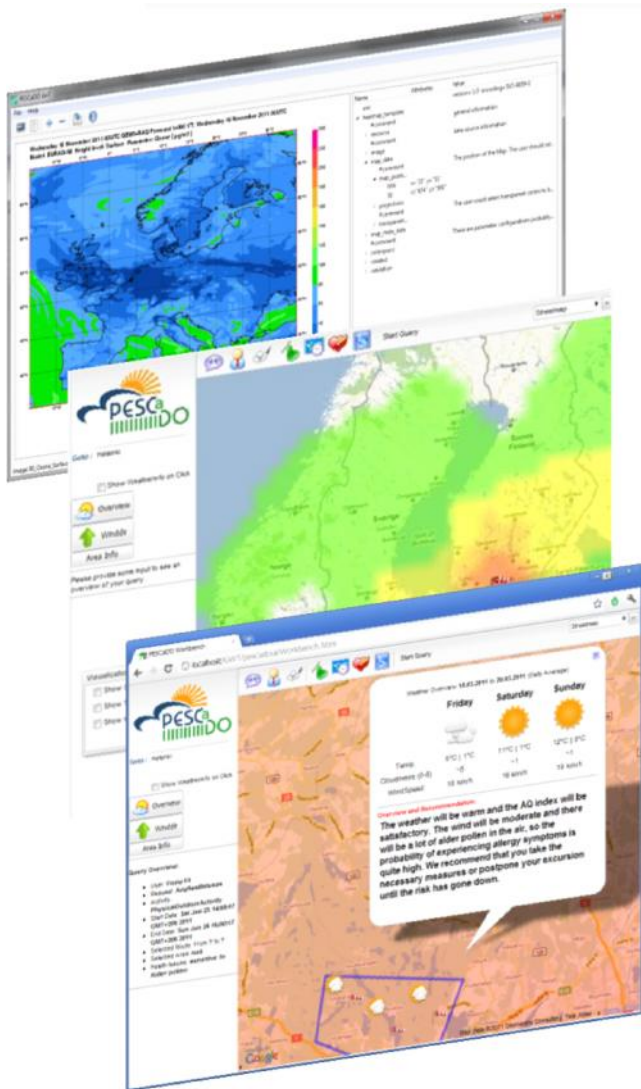
PESCaDO: Environmental Service Configuration and Delivery Orchestration

- Citizens are increasingly aware of the influence of **air quality** and **meteorological conditions** on the **quality of their life.**

- They need personalized, supportive and comprehensive information

Tomorrow evening cycling in Helsinki?

yes/no

?

Temperature

Precipitation

Pollen
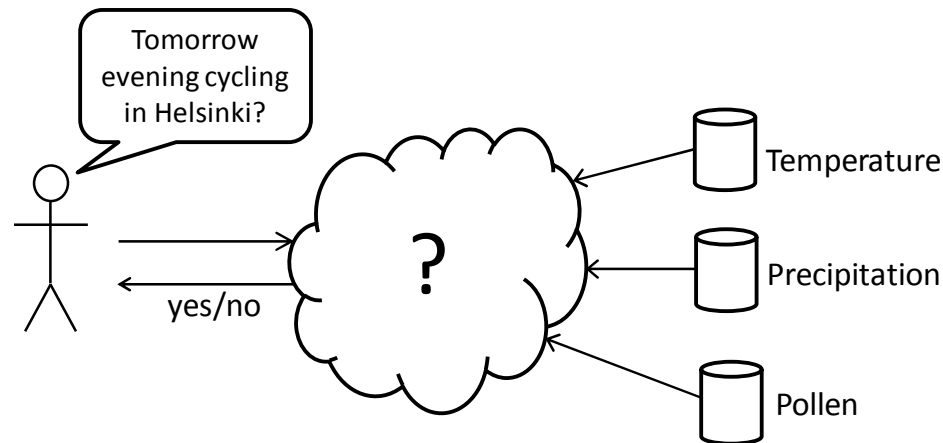
2010: FP7 ICT - CA

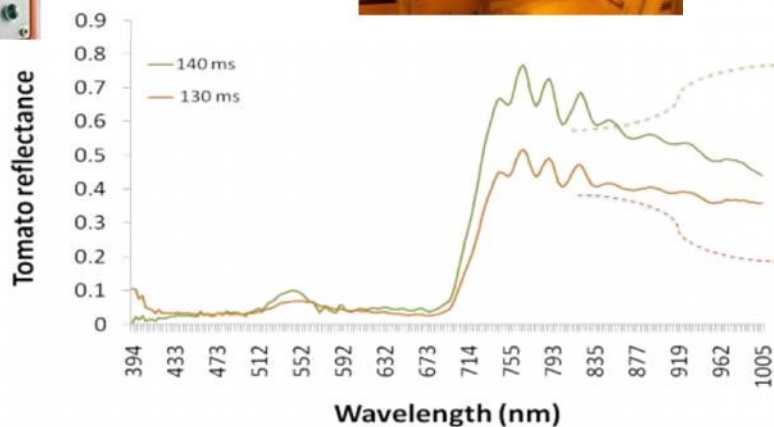## A Hyperspectral Imaging System for Plant Water Stress Detection

Scient. Resp. Constantinos Kittas, Prof. Un. Of Thessaly

Main Reseachers:
Dr. Thomas Bartzanas, Senior Researcher, CERTH / IRETETH
Dr. Nikos Katsoulas, Ass. Prof. Un. Of Thessaly

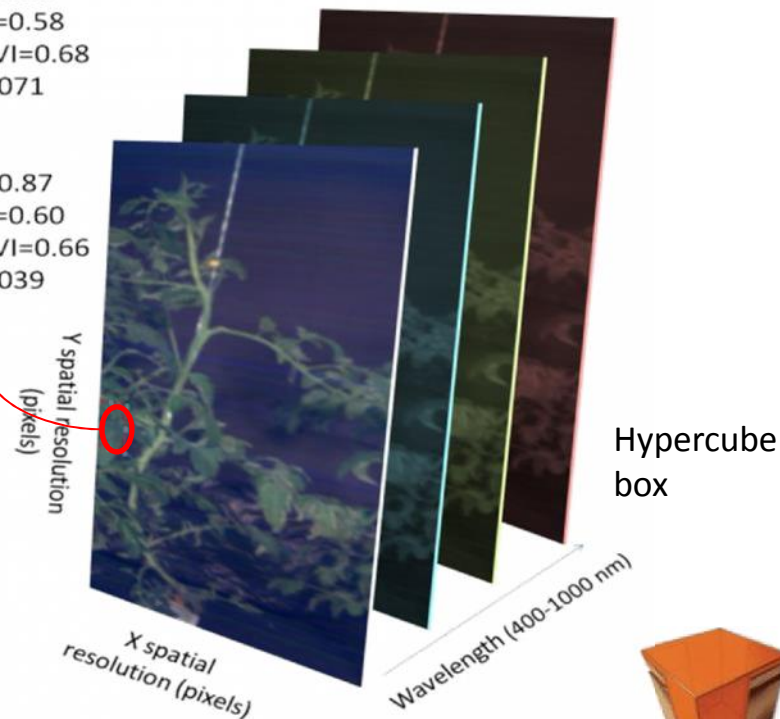*Funded under the GSRT project GreenSense, Aristeia*

- NDVI=0.86
- rNDVI=0.58
- mrNDVI=0.68
- PRI=0.071

- NDVI=0.87
- rNDVI=0.60
- mrNDVI=0.66
- PRI=0.039

$$r = \frac{R - D_\lambda}{W_\lambda - D_\lambda}$$

Y spatial resolution (pixels)

X spatial resolution (pixels)

Wavelength (400-1000 nm)

Hypercube box

➢ NDVI=(800-680)/(800+680)
➢ rNDVI=(750-705)/(750+705)
➢ mrNDVI=(750-705)/(750+705-2*445)
➢ PRI=(531-570)/(531+570)

140 ms
130 ms

Tomato reflectance
0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0

394 433 473 512 552 592 632 673 714 755 793 835 877 919 962 1005
Wavelength (nm)

Diverse Renewable Resources

Heterogeneous Sensors & Actuators

Advanced Monitoring & Control

Remote Sensing

- Solar irradiance
- Wind speed

Data Manipulation

Remote Control Actions

Optimum Prediction

Information Extraction

Model-based Decision Making

CERTH / PSDI

Sustainable Power Production Methodology

Process Systems Design & Implementation (PSDI) Lab
Director: Dr S. Voutetakis
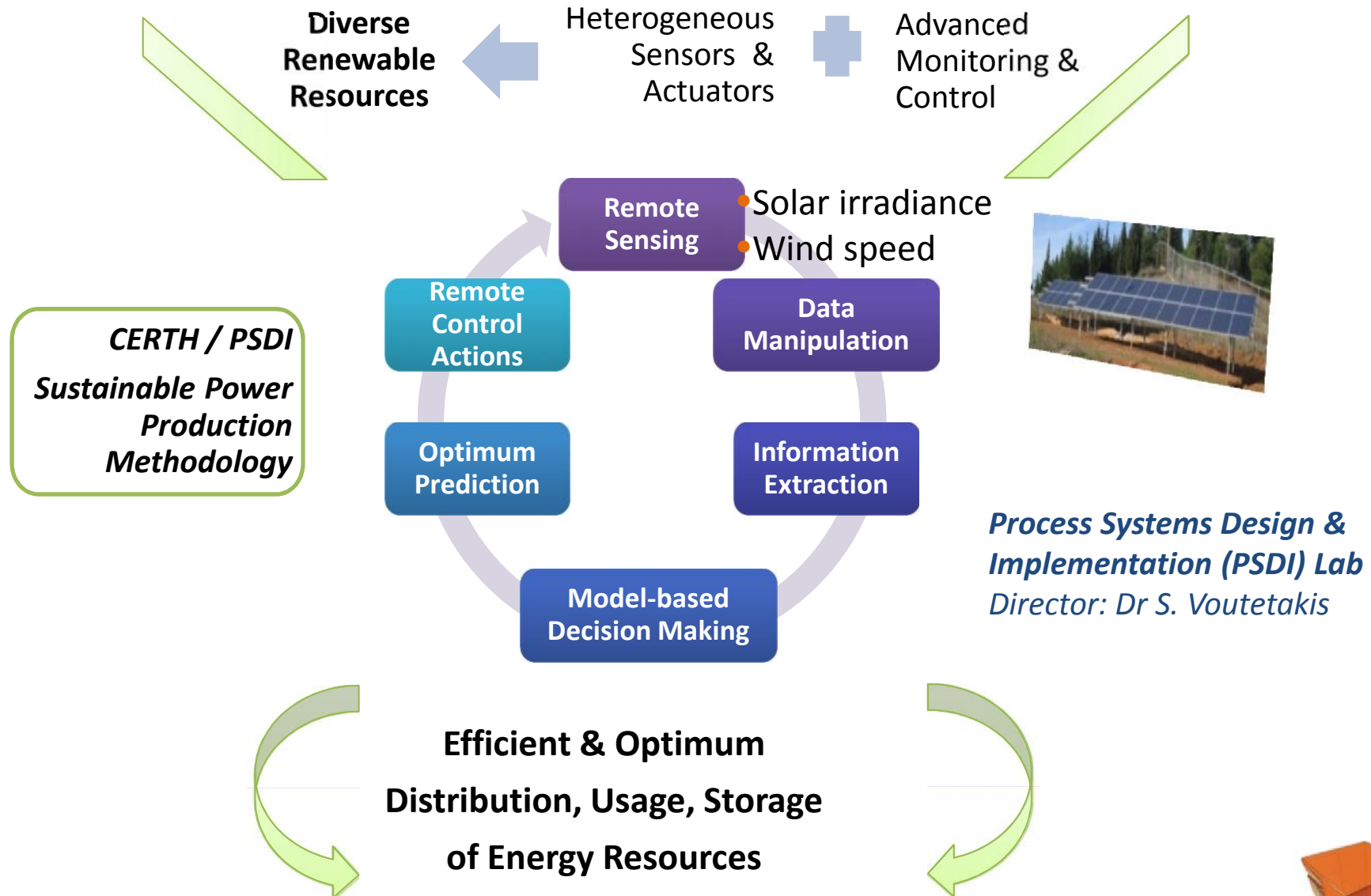
Efficient & Optimum Distribution, Usage, Storage of Energy Resources

# SERVICES

Remote Sensing Tools for Environmental Innovation

Services for

- the EEA, ESA
- Regional and local authorities
- SMEs' added value products
- Other users

- Environmental monitoring
- Impact analysis
- Cost benefit analysis
- Scenaria testing
- Risk analysis
- Mitigation measures design and implementation
- Warning signals issuance
- Post-exploitation design and impact monitoring
- Tourism promotion
- Precision farming practices incorporation into the cultivation management
- Capacity maximization
- Promotion of environmental sensitivity and protection
- etc…..
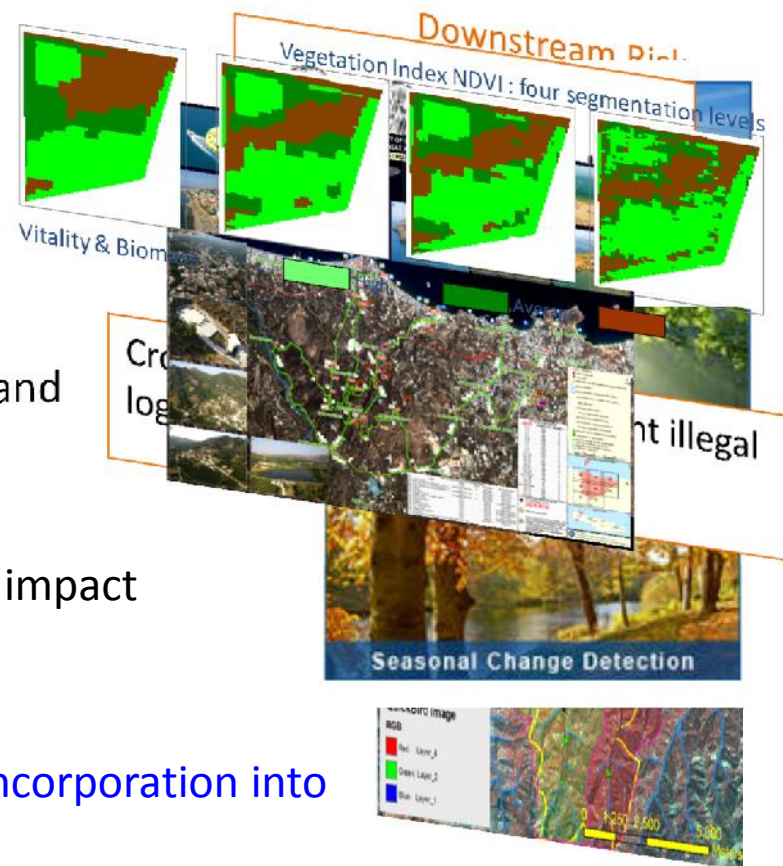
Actual and pursued activity fields @ CERTH - ITI

- **C**hange Detection & Times Series Analysis

- **V**ery high resolution and SAR image fusion

- **M**apping using latest active learning techniques

- **B**uilding up micro to macro level relationships

(reflectance vs. physicochemical features)

- **M**odeling for life & earth

- **Q**uantification of errors and uncertainty handling

- **A**pplications fields: Environment, Climate Change,

Food Security, Energy, Capacity Building/ Training,

Health, Security

imaging life - planning the future
applications support in CERTH-ITI

Life services	Biodiversity Habitats Health	
Geo services	Land Cover & Land Use Agriculture Forestry	
IT services	Modelling & Simulation Feature Extraction Uncertainty handling	

& training/capacity building at various levels

Maps
Reports
Scenaria

Consultancy
Advice
Guidance

Networking
Funds raising

International
Regional
National
Local

Remote Sensing Tools for Environmental Innovation
with a 😊 and a vision
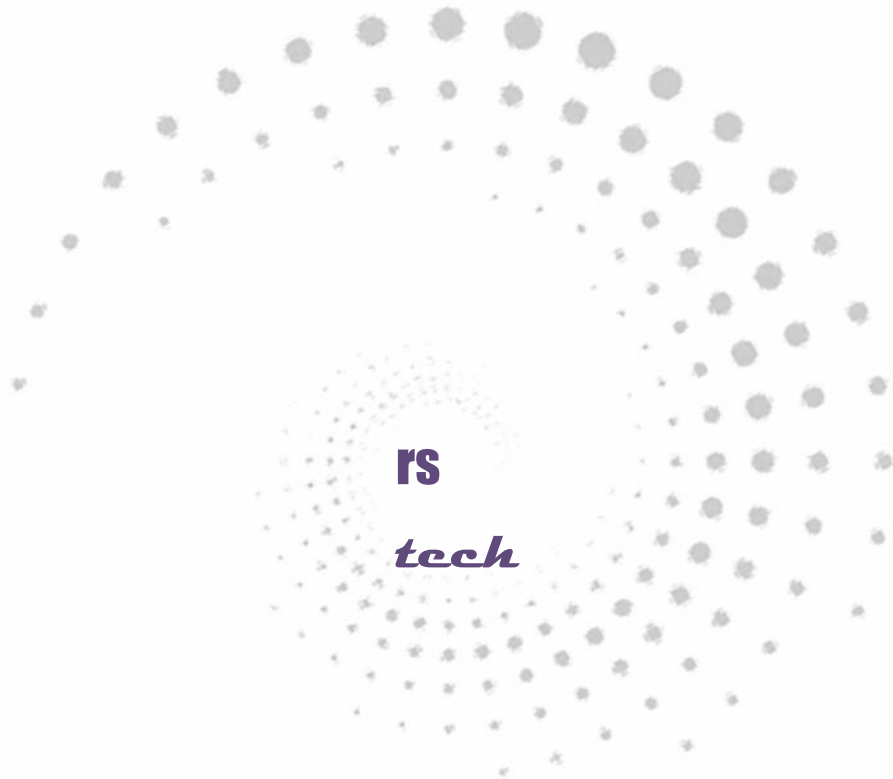
On behalf of my colleagues and with appreciation for your attention

At your disposal for questions/ clarifications

ioannis Manakos, CERTH-ITI
imanakos@iti.gr

www.iti.gr