Mapping of Olive Oil Mill Wastes through Geoinformation Technologies

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IMS, FORTH

Workshop on 4-Dimensional and High-Definition Geophysics
KIGAM, Daejeon, South Korea
December 11th-12th 2014

Publications

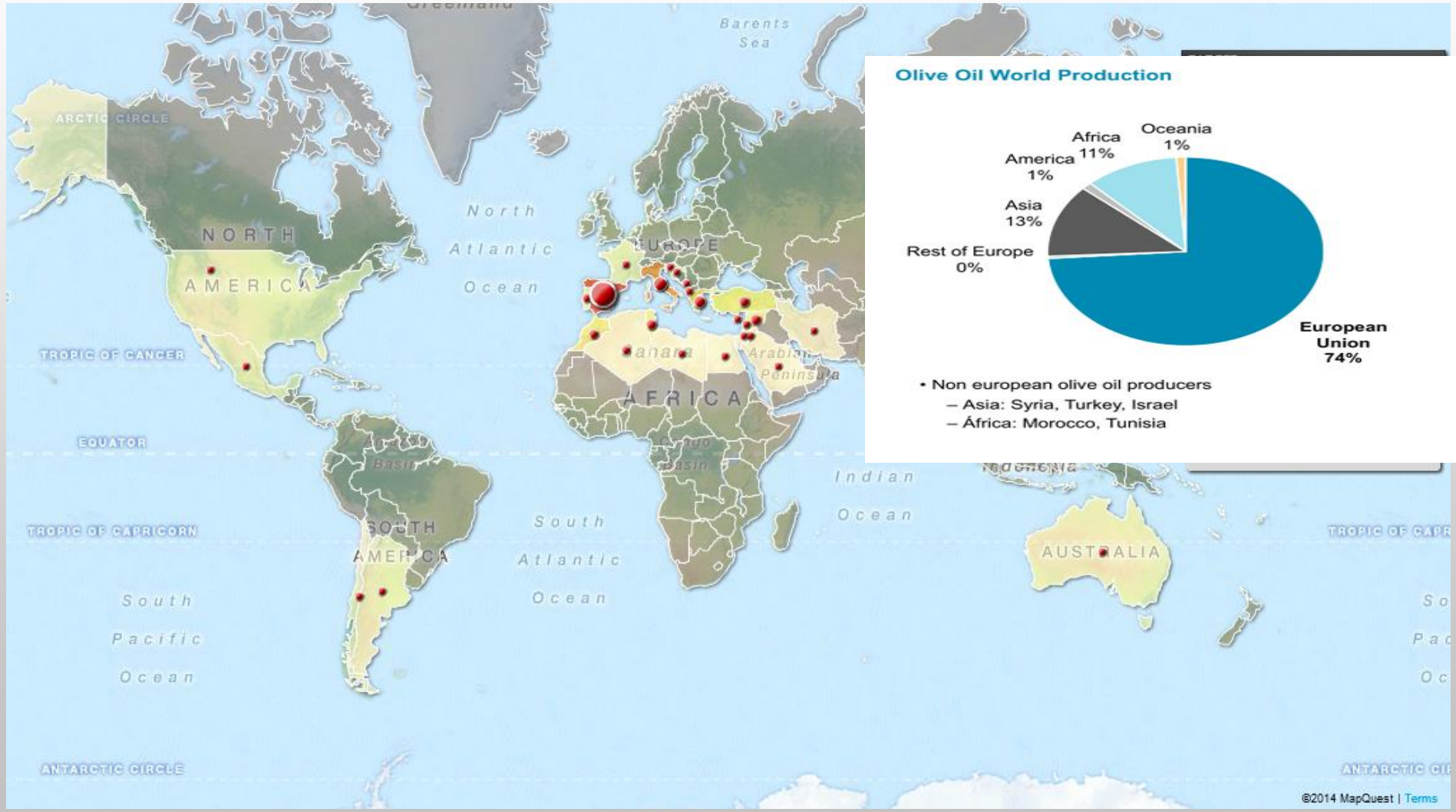
1. **ERT pollution monitoring in areas of olive oil mills' wastes (OOMW): Preliminary results from a disposal site in Crete (Greece) by** Nikos Papadopoulos and Stefanos Chatziathanasiou. *GELMON 2011 workshop, Vienna.*
2. **Olive-oil mill wastewater transport under unsaturated and saturated laboratory conditions using the geoelectrical resistivity tomography method and the FEFLOW model** by P. Seferou & P. Soupios & N. N. Kourgialas & Z. Dokou & G. P. Karatzas & E. Candasayar & N. Papadopoulos & V. Dimitriou & A. Sarris & M. Sauter, *Hydrogeology Journal, 2013, DOI 10.1007/s10040-013-0996-x*
3. **Monitoring of Olive Oil Mills' Wastes using Electrical Resistivity Tomography Techniques by** Simyrdanis Kleanthis, Papadopoulos Nikos, Kirkou Stella, Sarris Apostolos and Tsourlos Panagiotis *Second International Conference on Remote Sensing and Geoinformation 2014, 7-10 April 2014, Paphos, Cyprus*
4. **Mapping of Olive Oil Mills' Wastes (OOMW) through Electrical Resistivity Tomography: A case study from Alikianos site in eastern Crete (Greece)** by Nikos Papadopoulos, Pantelis Soupios, Jung-Ho Kim, Kleanthis Simirdanis, Stella Kirkou, Panagiotis Tsourlos. *20th European Meeting of Environmental and Engineering Geophysics Athens, Greece, 14-18 September 2014*
5. **Development of automated satellite remote sensing and ground spectroscopy techniques for monitoring olive oil mill waste disposal areas in Crete-Greece** by Dimitrios D Alexakis, Apostolos Sarris, Chariton Kalaitzidis, Nikos Papadopoulos, Pantelis Soupios, *submitted to Sensors*
6. **GEODIAMETRIS: AN INTEGRATED GEOINFORMATIC APPROACH FOR MONITORING LAND POLLUTION FROM THE DISPOSAL OF OLIVE OIL MILL WASTES by** Dimitrios D. Alexakis, Apostolos Sarris, Nikos Papadopoulos, Pantelis Soupios, Maria Doula , Victor Cavvadias, Sideris Theocharopoulos. *Second International Conference on Remote Sensing and Geoinformation 2014, 7-10 April 2014, Paphos, Cyprus*
7. **Time lapse ERT monitoring of Olive-oil mills' wastes (OOMW) using simulation and experimental data** by S. Kikrou, P. Tsourlos, N. Papadopoulos, P. Soupios and J-H Kim. *20th European Meeting of Environmental and Engineering Geophysics Athens, Greece, 14-18 September 2014*

Worldwide Olive Oil Production

The olive oil production industry represents an important activity worldwide

Based on the average production the last 6 years (2007 to 2013)

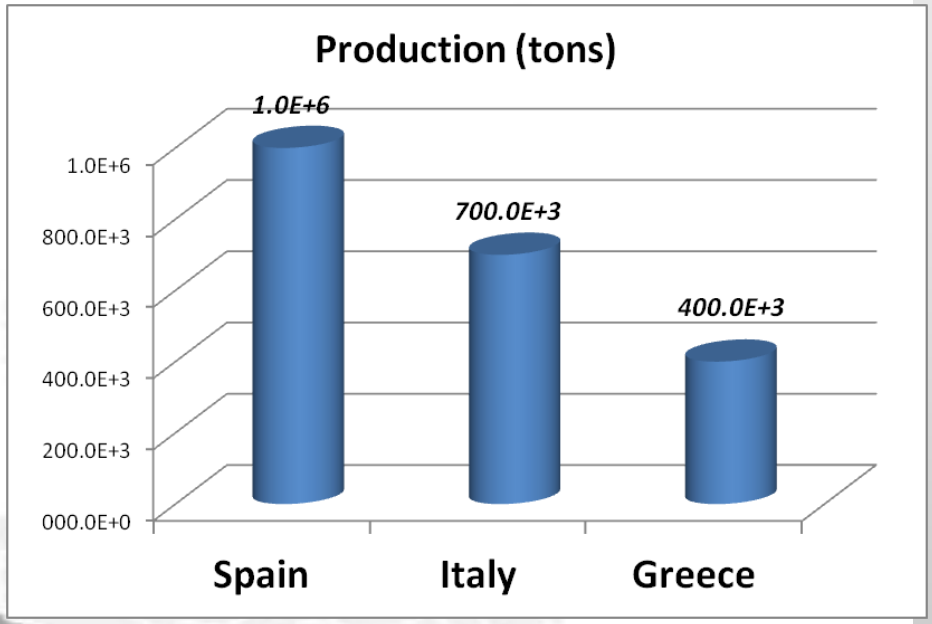
- Annual Olive Oil Production: **~ 3 million tons**

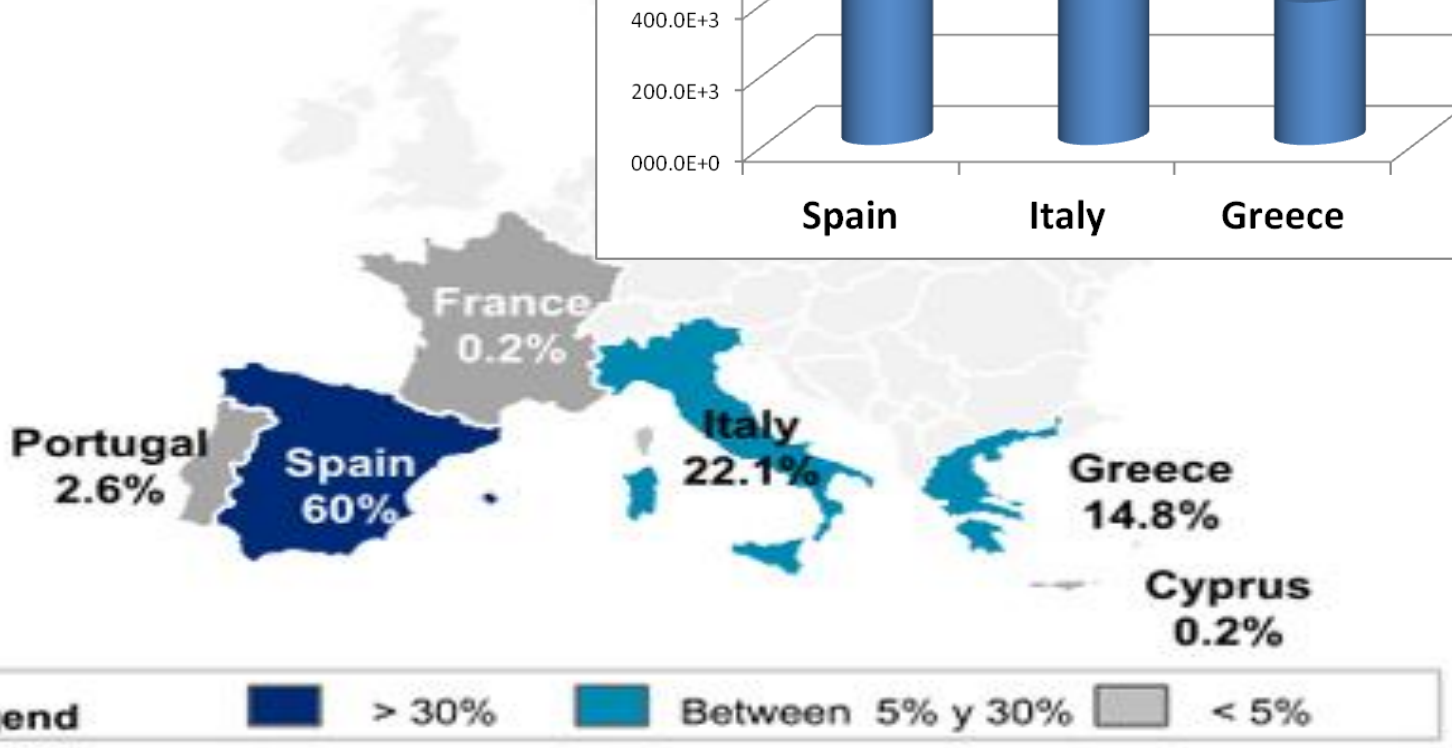


Worldwide Olive Oil Production

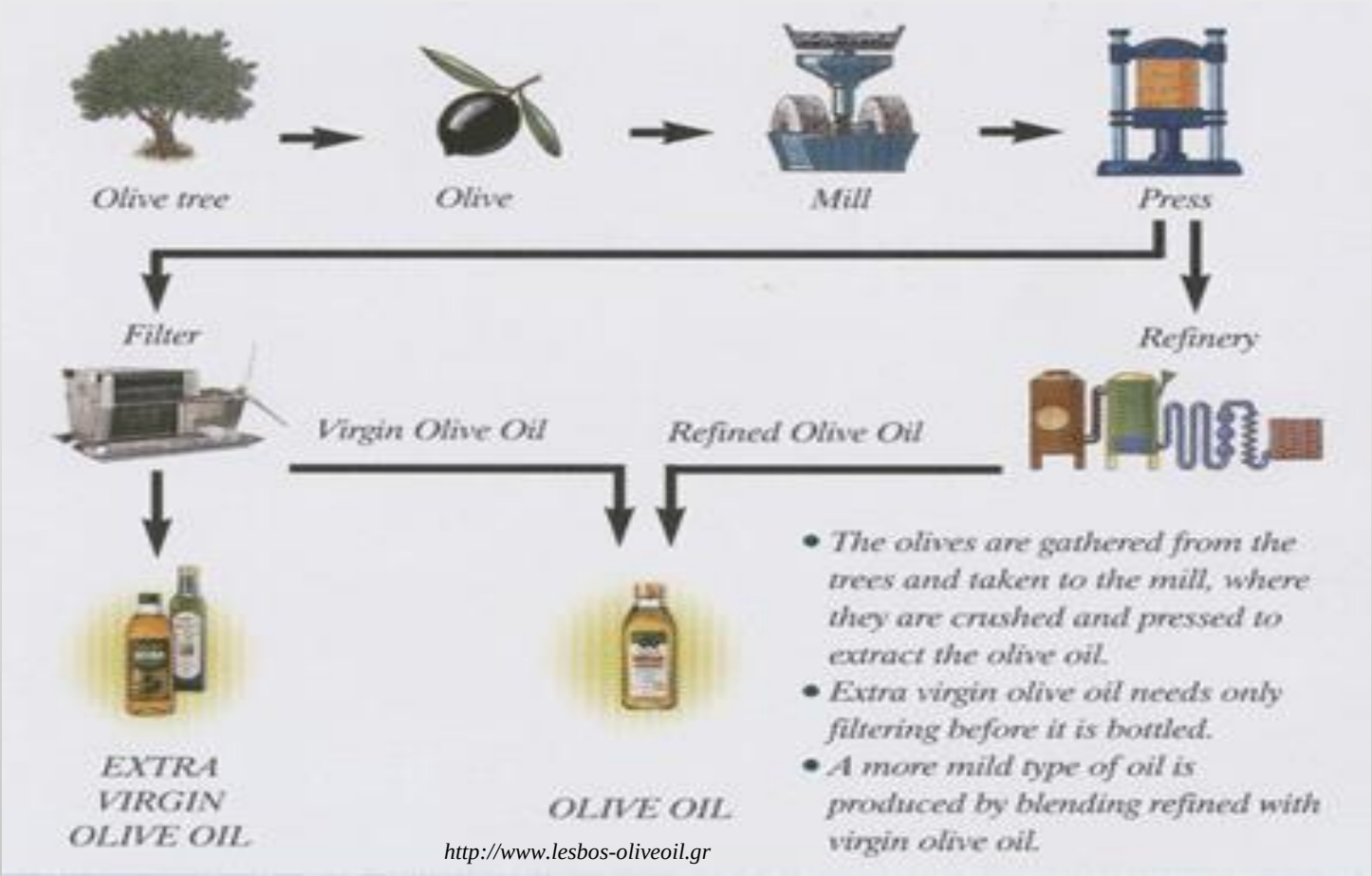
European Union Olive Oil production.

http://www.intercountries-exchanges.com





Olive Oil Production Process



http://www.lesbos-oliveoil.gr

Olive Oil Mills' Wastes (OOMW)

huge waste production in a relatively short time

1 of ton olive oil production → ~1.5 ton dry organic pollutants

Physico-chemical characteristics

- Dark brown color, foul-smelling and turbid liquid
- Includes emulsified grease
- High Biochemical Oxygen Demand (BOD-40-95 g/l)
- High Chemically Oxygen Demand (COD-50-180 g/l)
- Phenolic compounds (<700 mg/Kg)
- High organic content (proteins & sugar, <55%)
- Acid PH (<6)
- **Conductive material (<5 Ohm-m**)




Disposal of OOMW

Main Methods

- **Evaporation ponds**
- Disposal in soil and torrents
- Incineration given the high organic load (fuels cost, gas emissions)

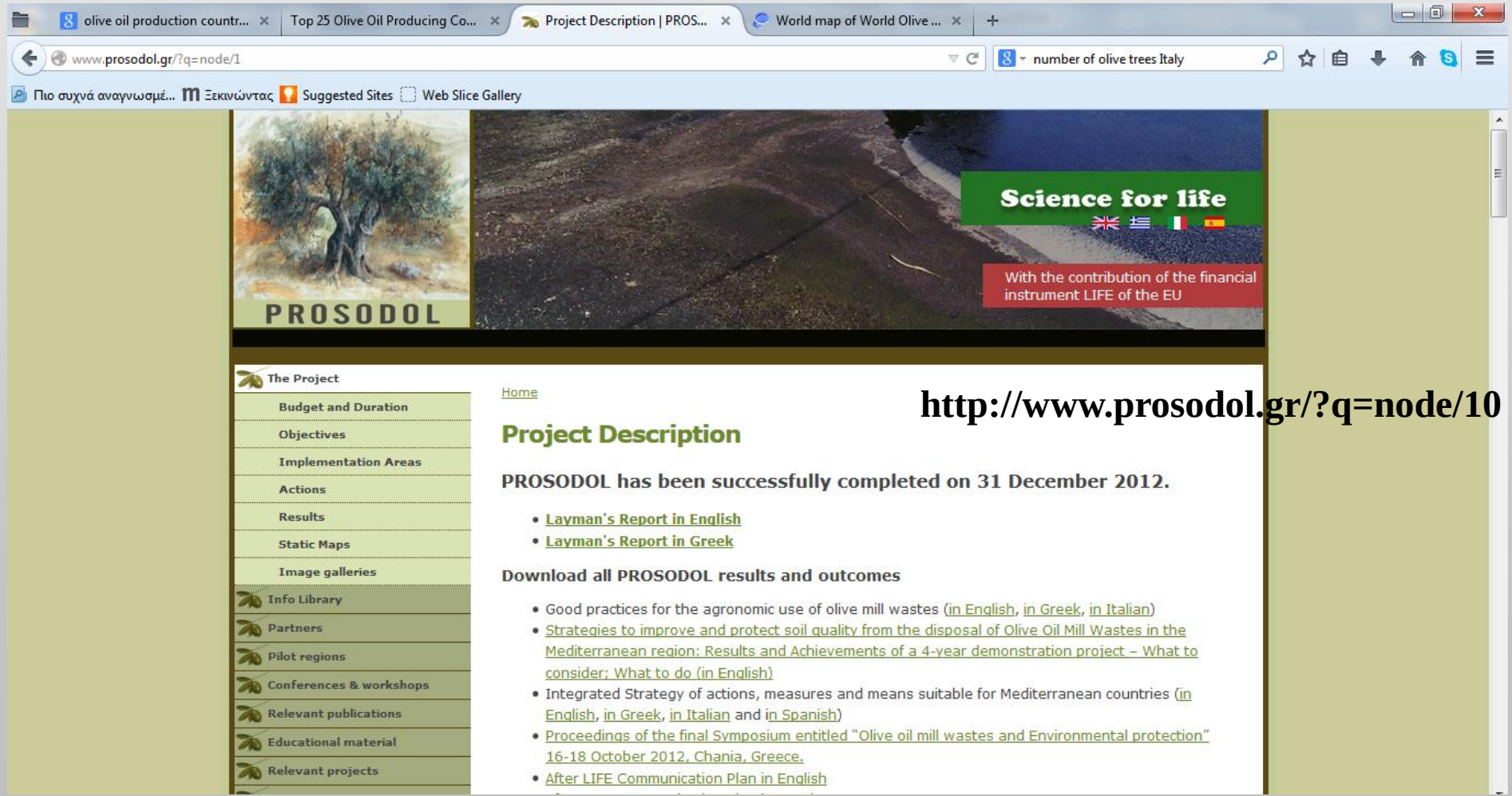
- **OOMW are toxic due to their phenolic compounds**
- **The presence of OOMW in soil causes phytotoxic and antimicrobial effects, while in rivers decreases the dissolved oxygen content**
- **The long-term deposition of OOMW can lead to future serious degradation of soil and groundwater quality**

PROSODOL Project

Main Objective

Manage and treat OOMW prior disposal

The development and implementation of technologies to protect and improve degraded soils with the use of zeolites and bioremediation methodology



http://www.prosodol.gr/?q=node/10

GeoDiaMetris

Integrated Geoinformatics Technologies for Time-Lapse Monitoring of Land Pollution from Disposal of Olive-Oil Mill Wastes (OOMW)

GeoDIAMETRIS Partners

Department of Natural Resources & Environment Technological Educational Institute of Crete Project Coordinator	
Laboratory of Geophysical – Satellite Remote Sensing & Archaeo-environment Institute for Mediterranean Studies (I.M.S) Foundation for Research & Technology (F.O.R.T.H.)	GeoSat ReSeArch Lab of Geophysical-Satellite Remote Sensing and Archaeoenvironment FORTH Institute for Mediterranean Studies
Soil Science Institute of Athens Hellenic Agricultural Organization-DEMETER	NAGREF
Department of Geophysics School of Geology - Aristotle University of Thessaloniki (AUTH)	SCHOOL OF GEOLOGY AUTH
Korea Institute of Geoscience and Mineral Resources Geoelectric Imaging Laboratory	KIGAM
Dept. of Earth and Environmental Sciences Rutgers University	THE STATE UNIVERSITY OF NEW JERSEY RUTGERS

KRIPIS –PEFYKA:

Environment and Natural Disasters: New methods to evaluate and improve the quality of the environment and to cope with natural disasters

Objectives

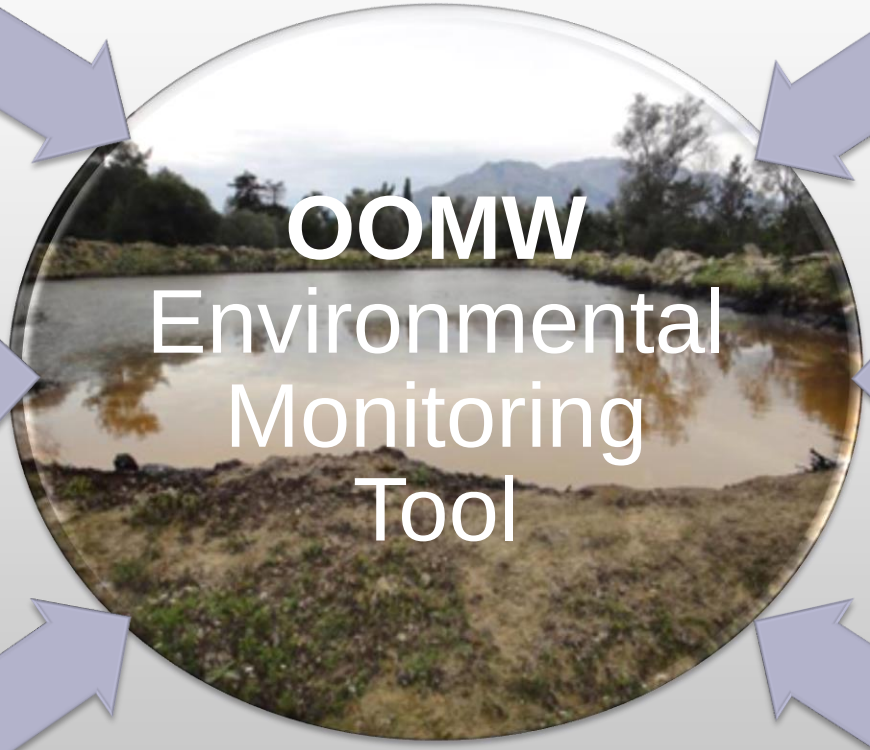
- The development and application of innovative methods, experimental devices and numerical tools to analyse, monitor, protect and improve the quality of the natural and urban environment
- The study, prediction and confrontation of natural disasters and the impact of the climate change

Concept of Mapping OOMW

GPS Mapping

Satellite Remote Sensing

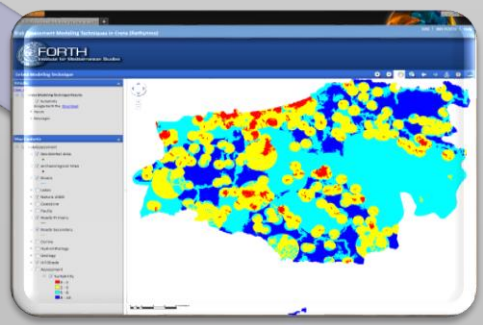
Soil sampling



Chemical Analyses

Geophysical Monitoring

GIS Risk Assessment Modeling



Area of Application - CRETE

- Crete contributes approximately 5% to the total world olive oil production

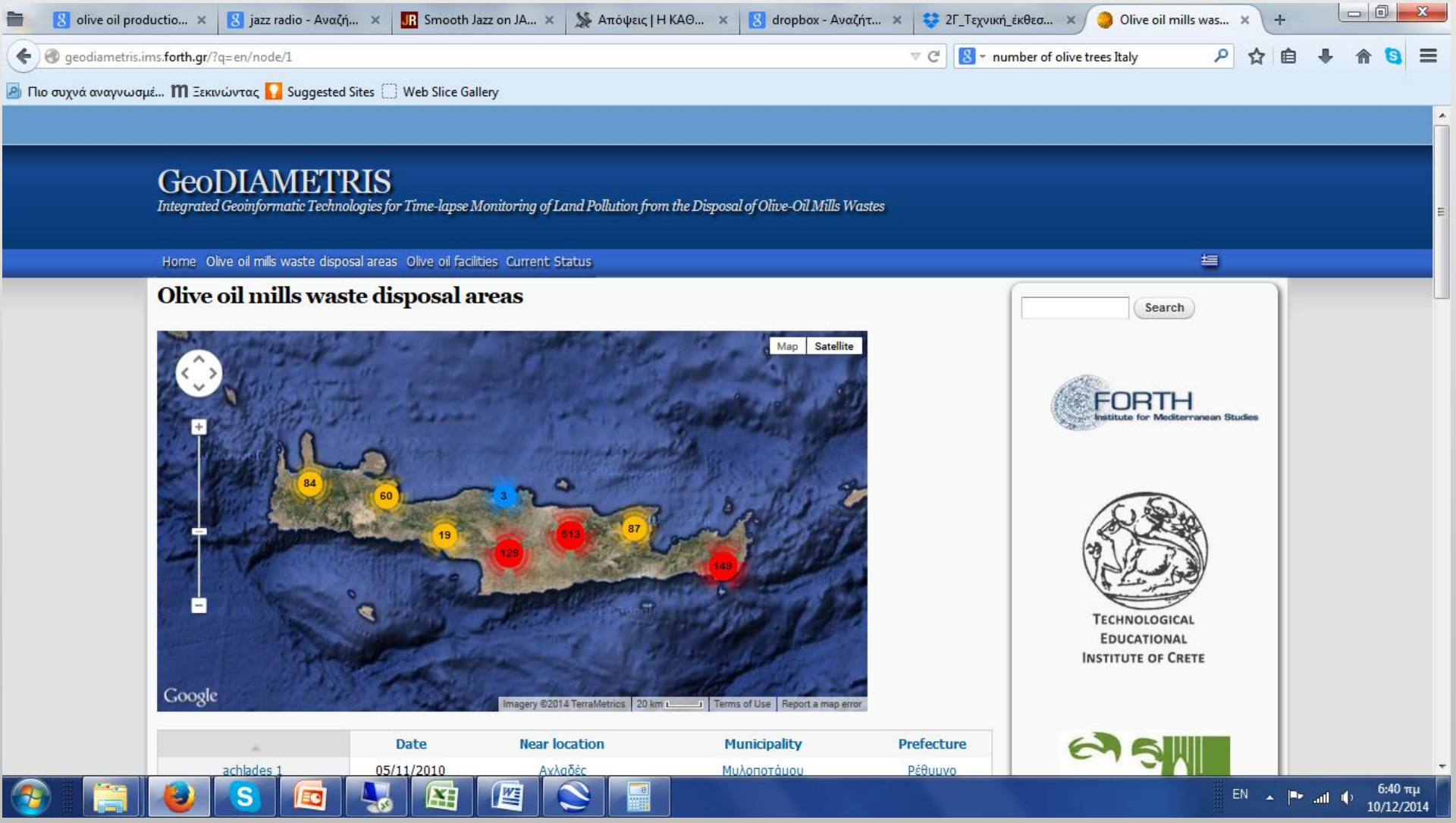
GPS Mapping for Recording the current Situation of Olive Mills and OOMW Disposal Sites

GPS Mapping – Web Data Base

- Olive Oil Facilities – Mills: **More than 540**

GPS Mapping – Web Data Base

- OOMW Disposal Sites: **More than 1000**



GPS Mapping – Web Data Base

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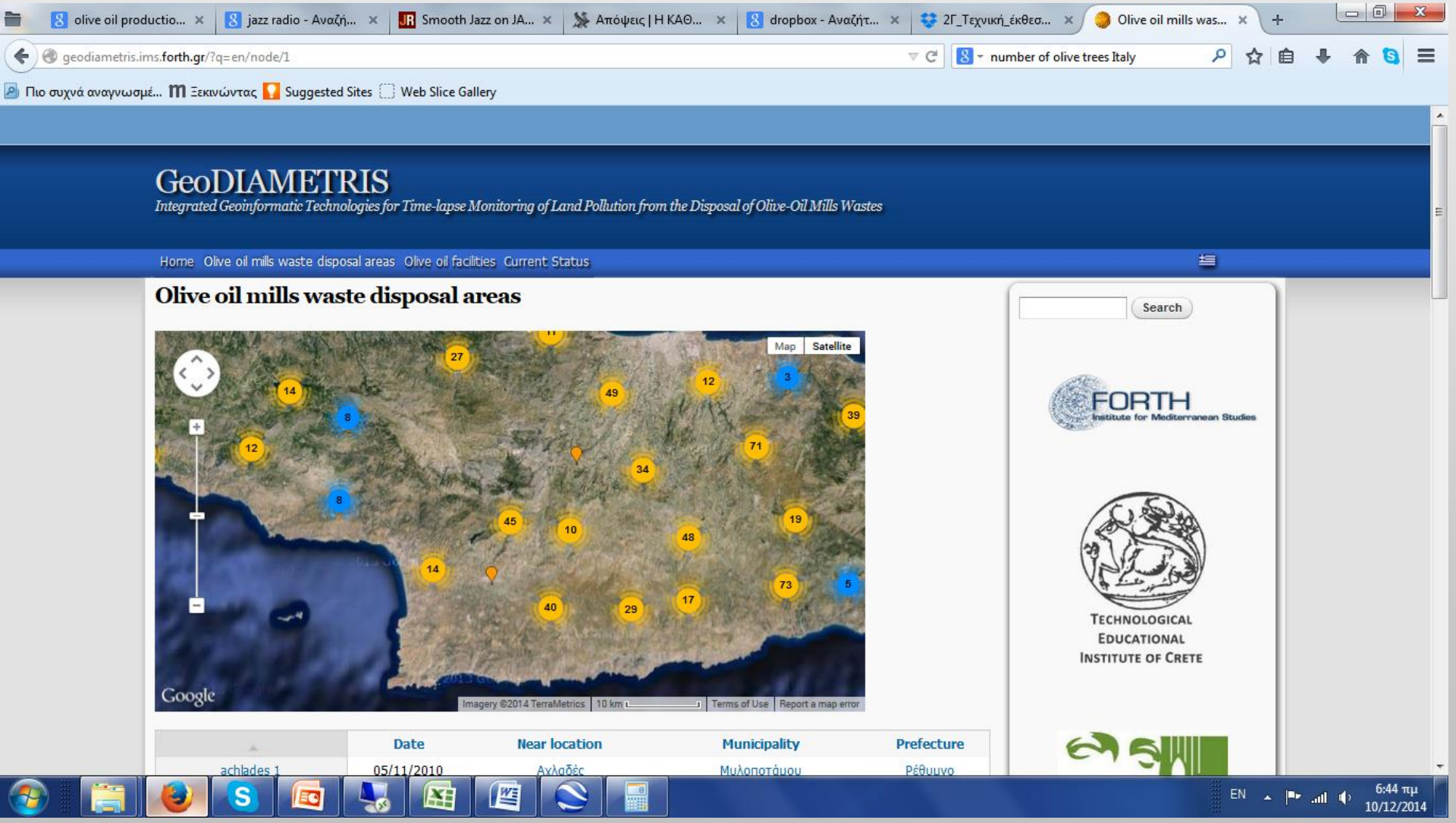

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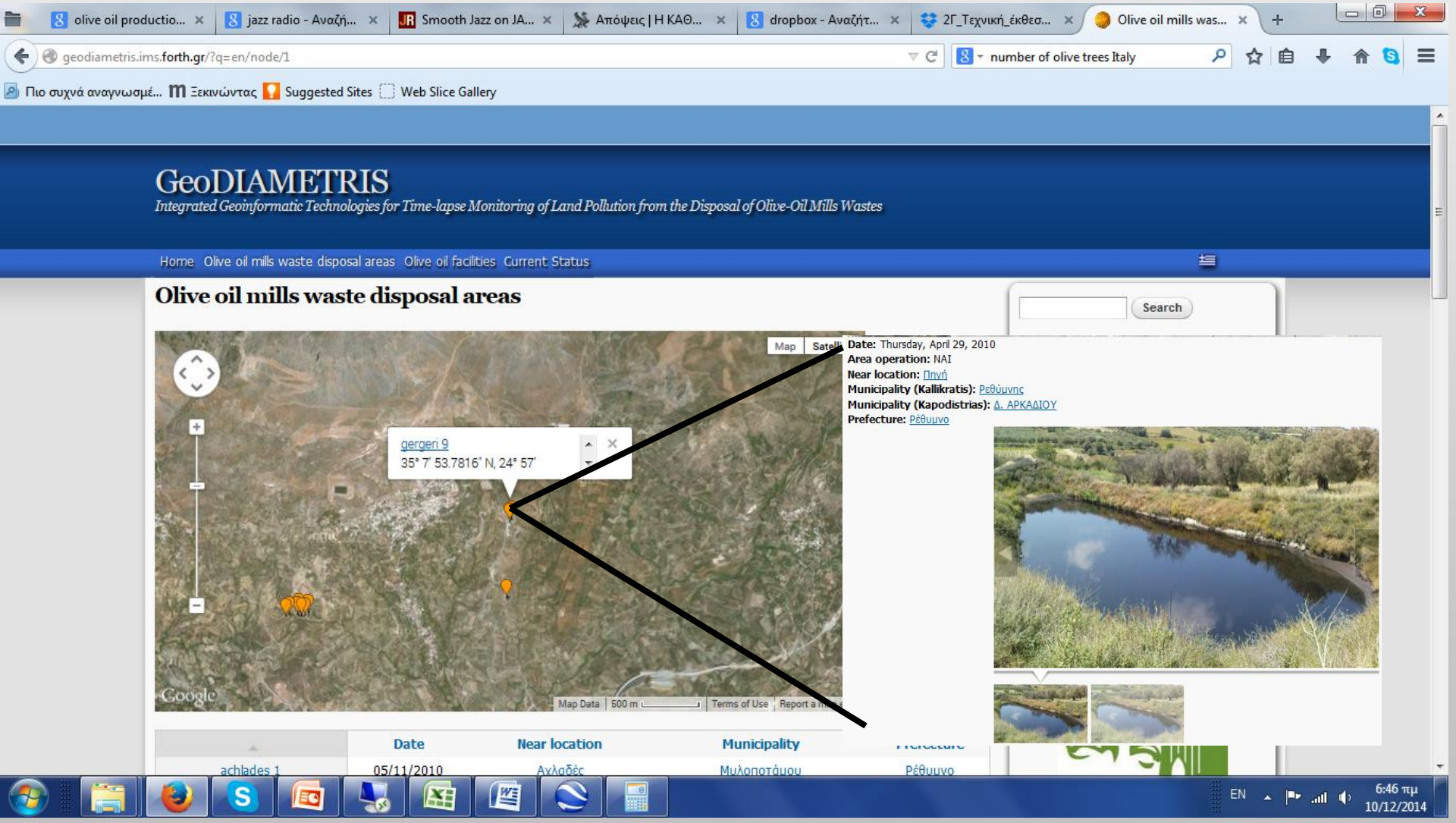


Satellite Remote Sensing for the Identification of OOMW Disposal Sites

Satellite Remote Sensing

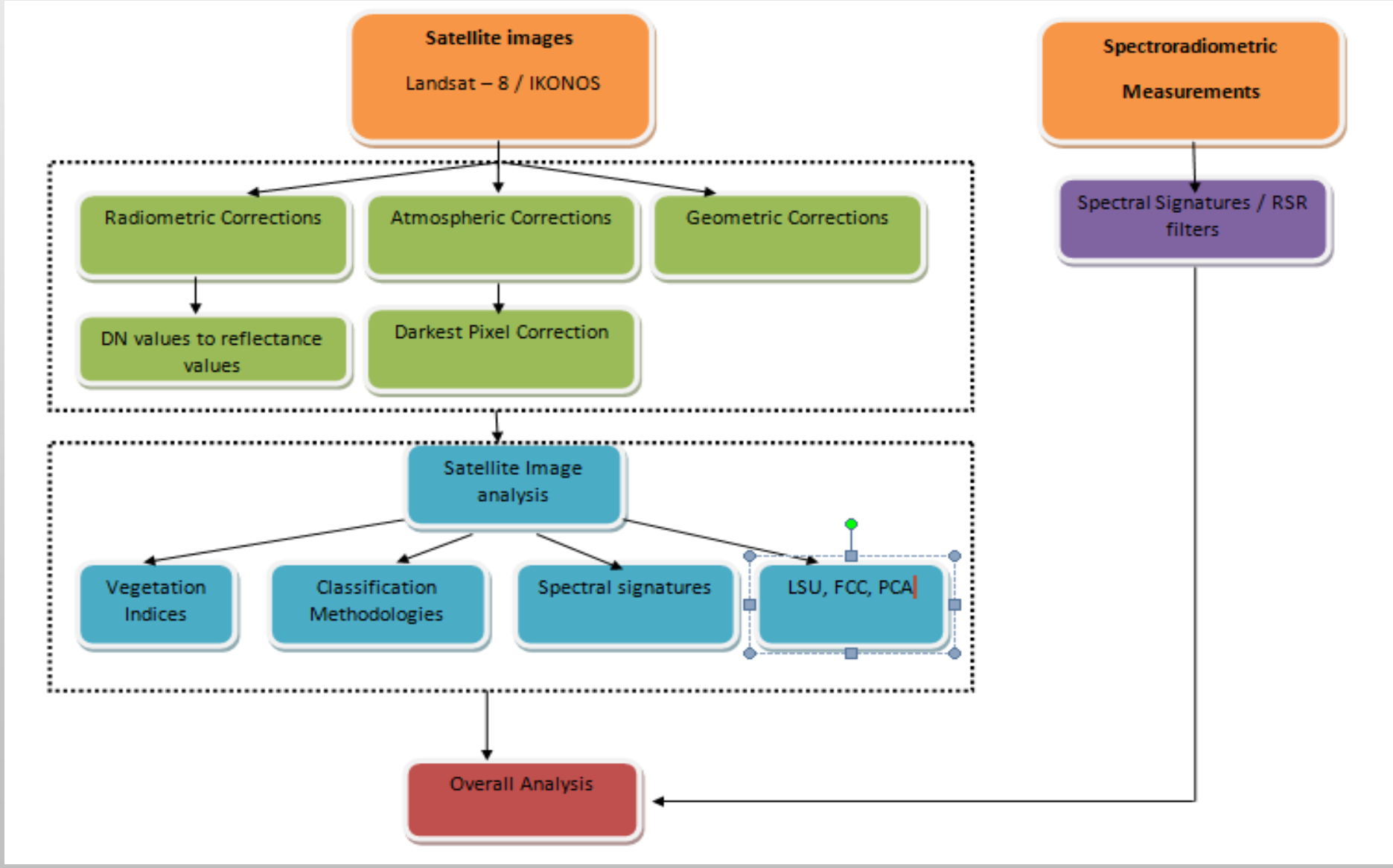
Landsat 8: 11 bands with spatial resolution of 30m on the visible spectrum and 15m for the panchromatic band

IKONOS: 0.8m panchromatic & 4m multispectral

	Satellite Image	Area	Date of Acquisition
1	Landsat 8	Western Crete	12/07/2013
2	Landsat 8	Western Crete	06/08/2013
3	Landsat 8	Western Crete	23/04/2013
4	Landsat 8	Eastern Crete	21/07/2013
5	Landsat 8	Eastern Crete	30/09/2013
6	Landsat 8	Eastern Crete	02/05/2013
7	IKONOS	Western Crete	27/07/2006
8	IKONOS	Western Crete	27/07/2006
9	IKONOS	Western Crete	20/03/2007

Satellite Remote Sensing

Processing

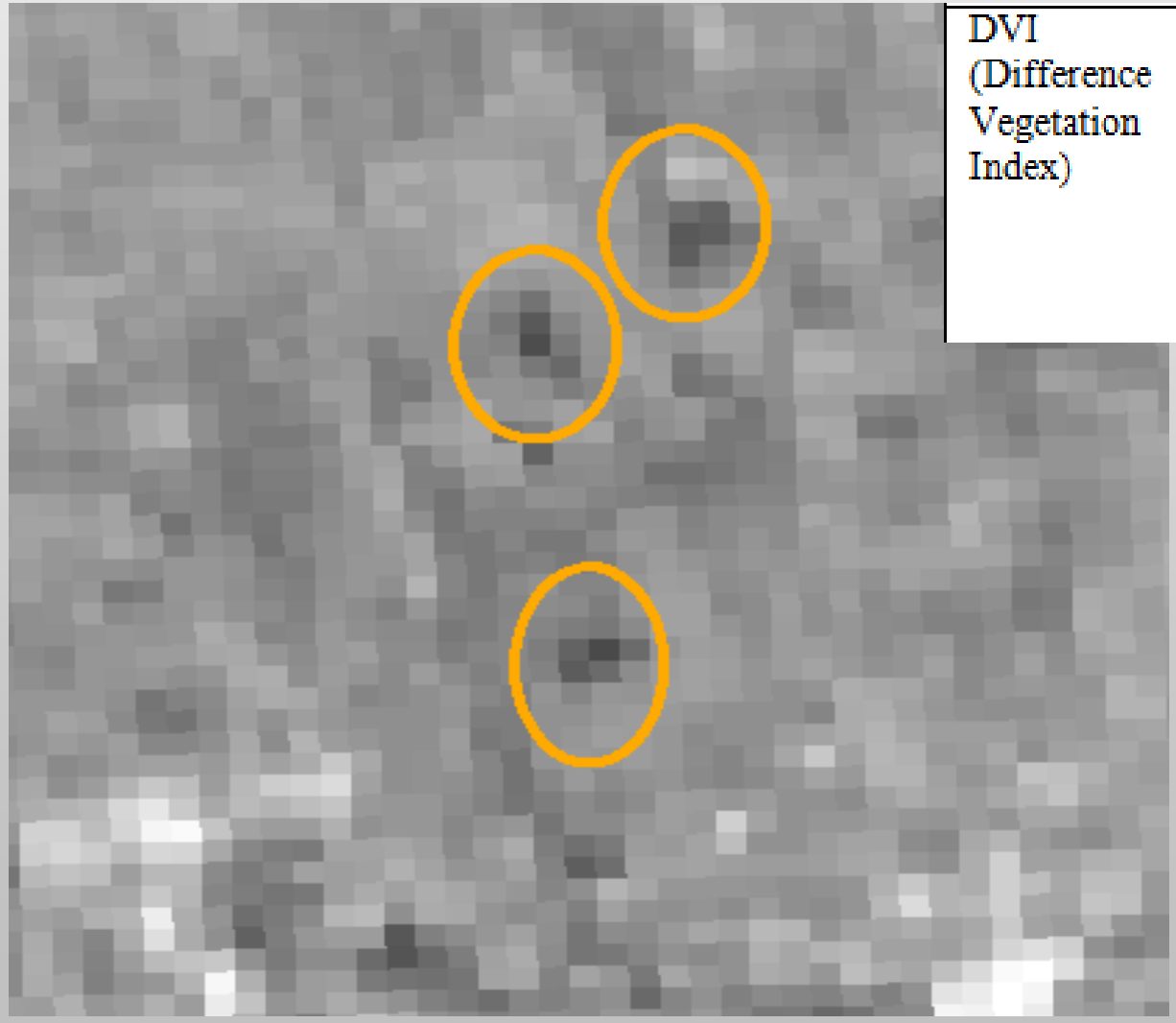


False Color Composites

FCC RGB– 321

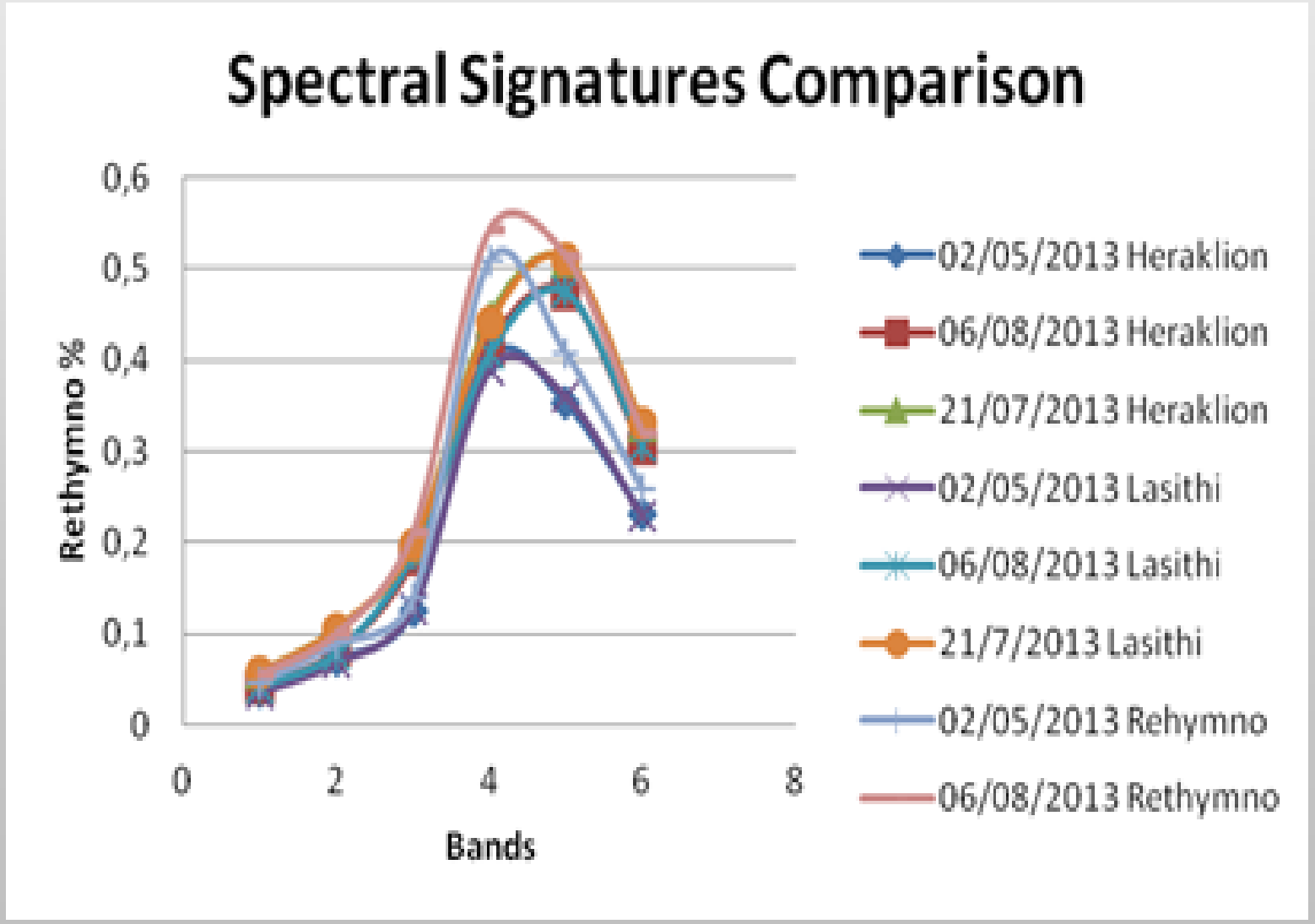
FCC RGB– 541

Vegetation Indices

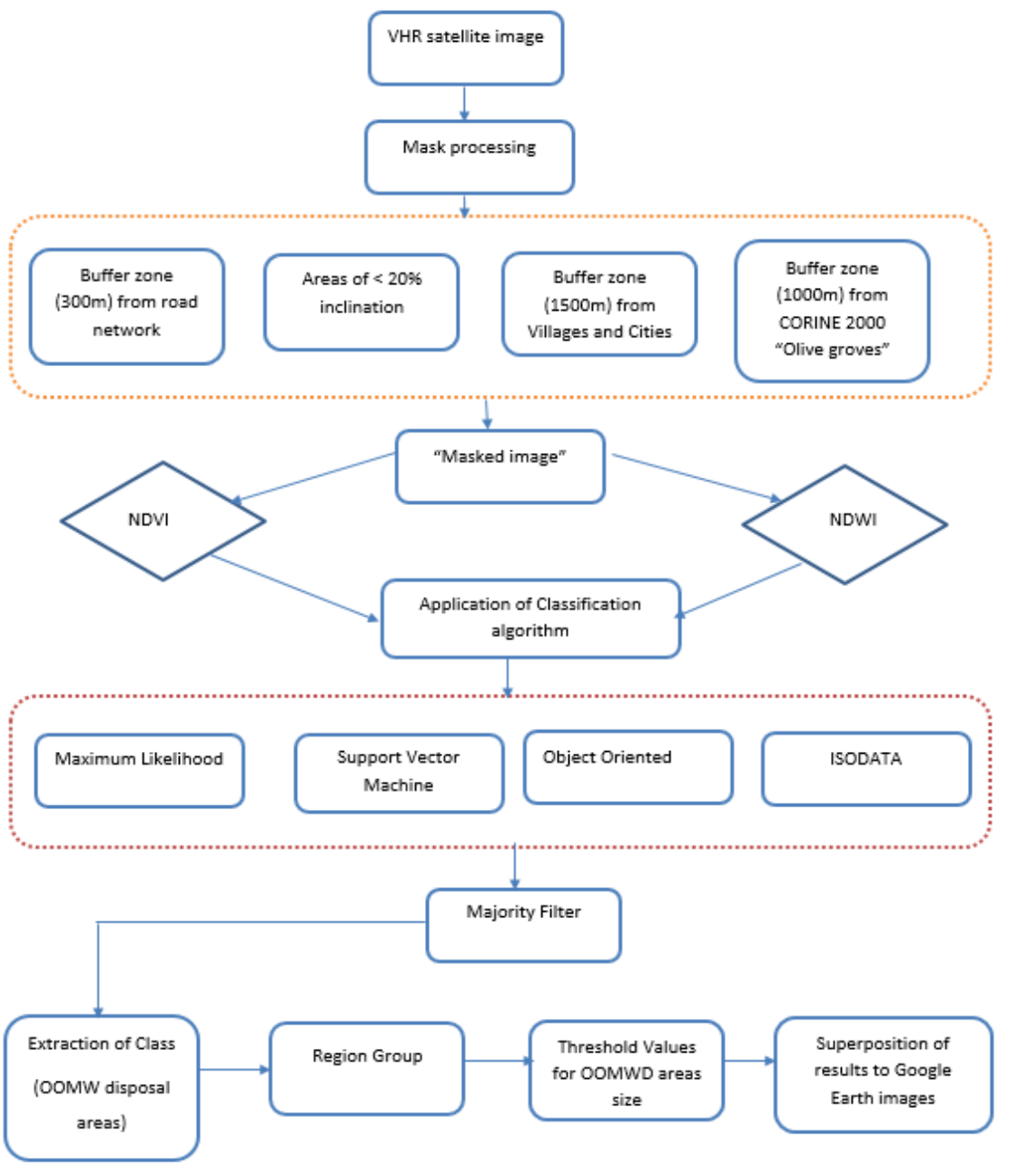


DVI (Difference Vegetation Index)	$p_{NIR} - p_{RED}$

Extraction of Spectral Signatures



Satellite Remote Sensing



Semi-automatic Methodology for the Detection of OOMW Disposal Areas

1. Spatial mask the satellite images based on certain environmental and anthropogenic parameters *(proximity to roads/villages, low inclination, corine land use maps)*

2. Application of different classification algorithms *(object oriented, ISODATA, Maximum Likelihood)*

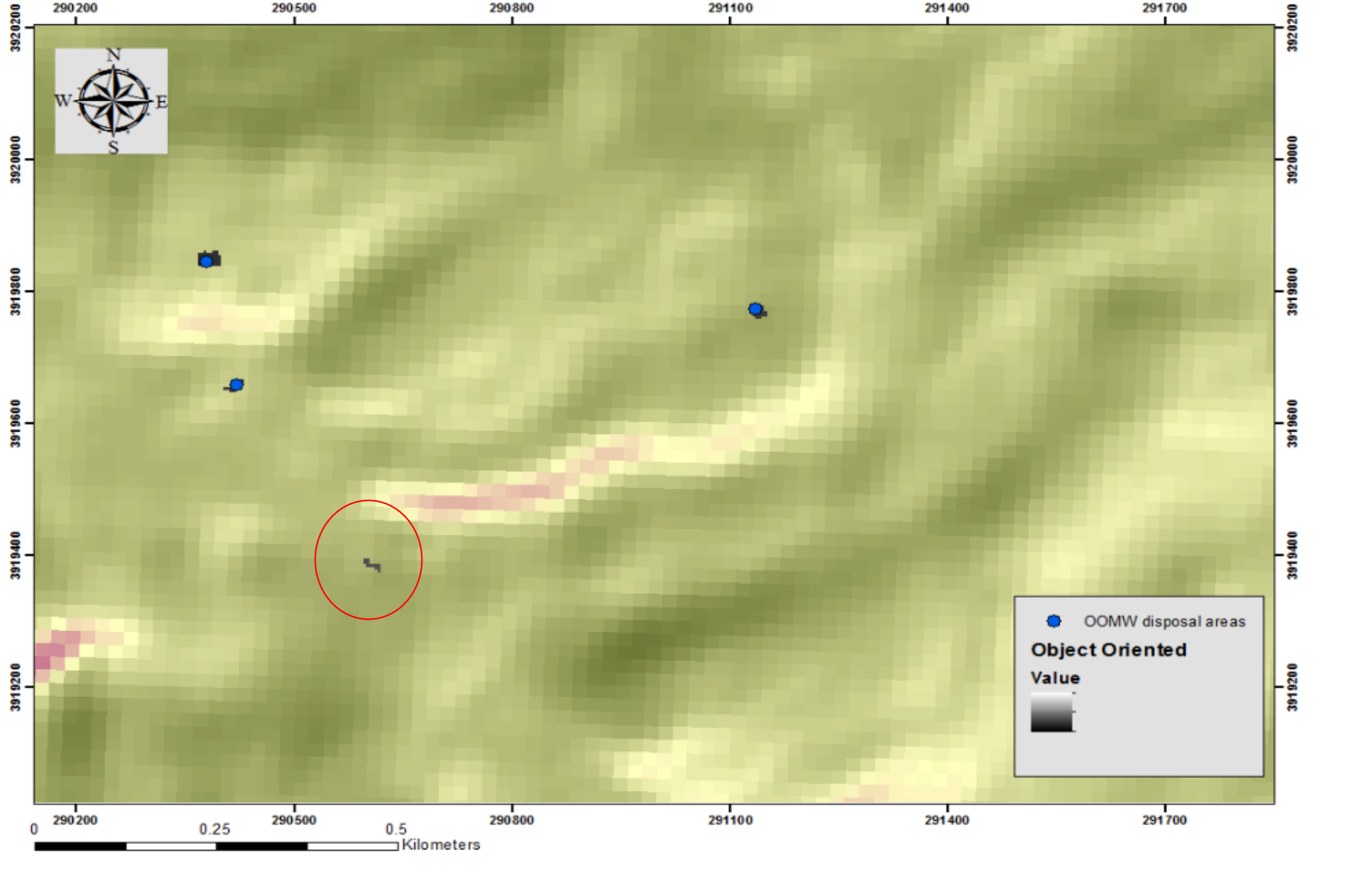
3. Application of certain threshold values to classification products

Satellite Remote Sensing

Semi-automatic Methodology for the Detection of OOMW Disposal Areas

Satellite Remote Sensing

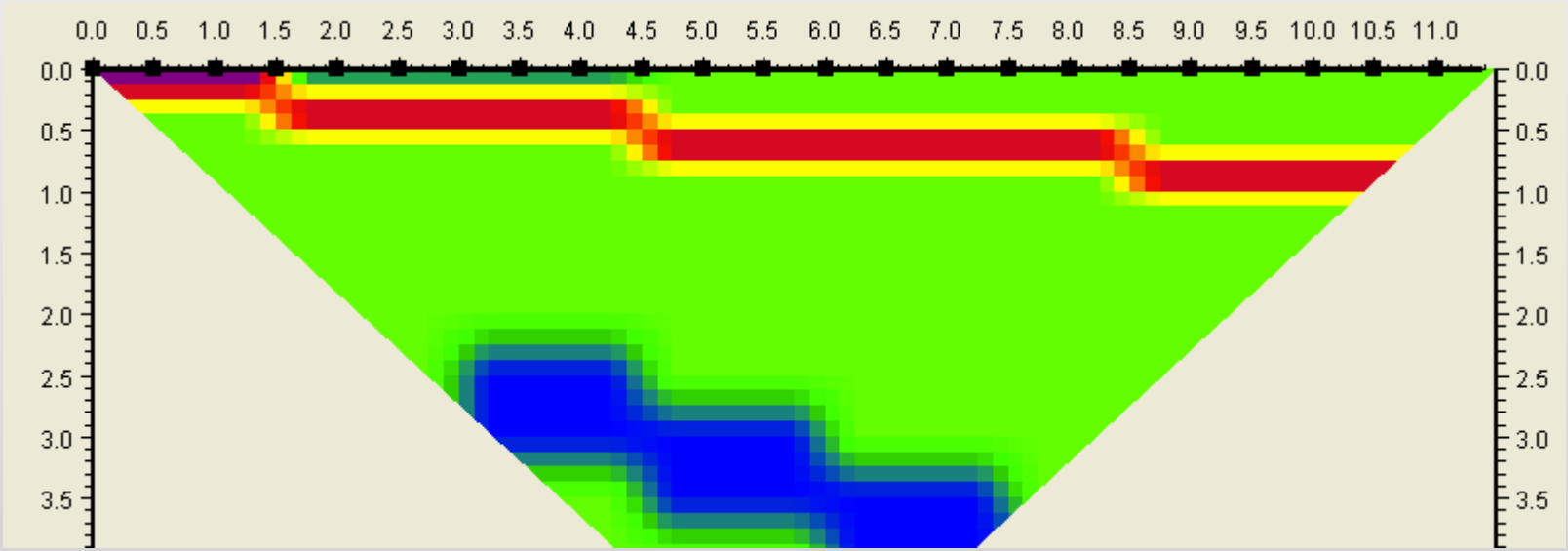
Semi-automatic Methodology for the Detection of OOMW Disposal Areas



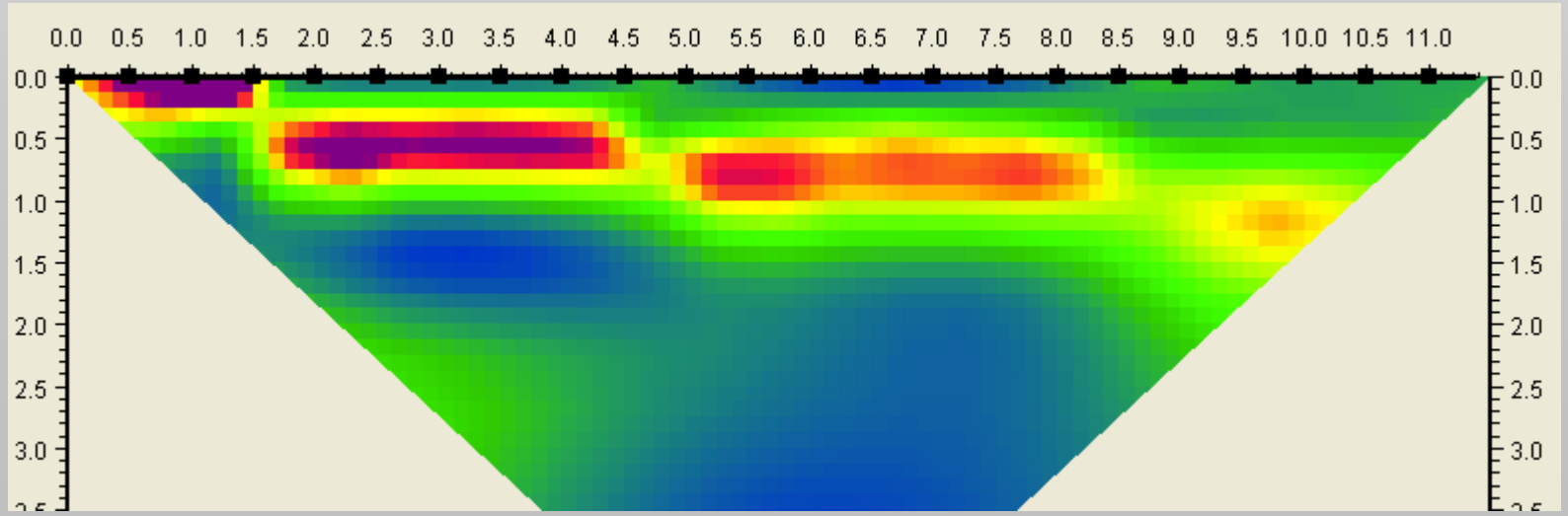
Geophysical Mapping & Monitoring

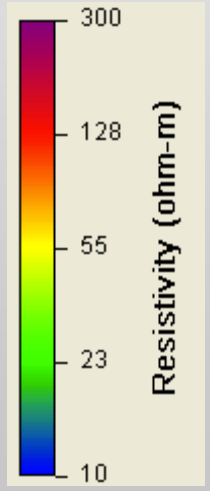
Synthetic Surface ERT Modeling

Original Model



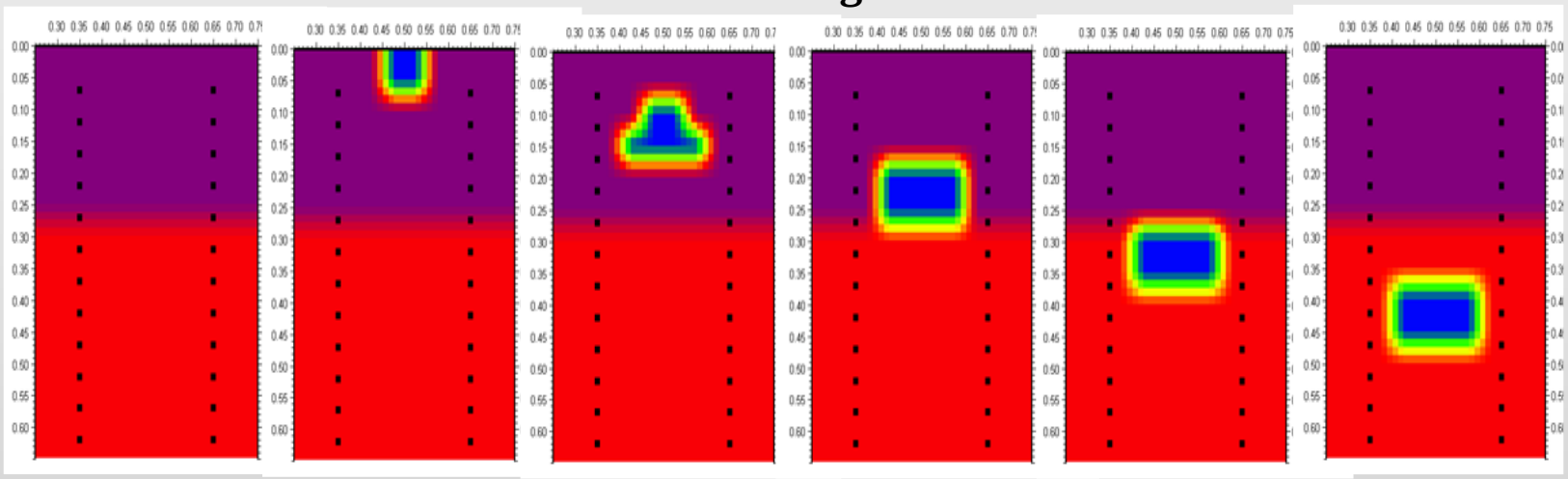
2-D inversion model



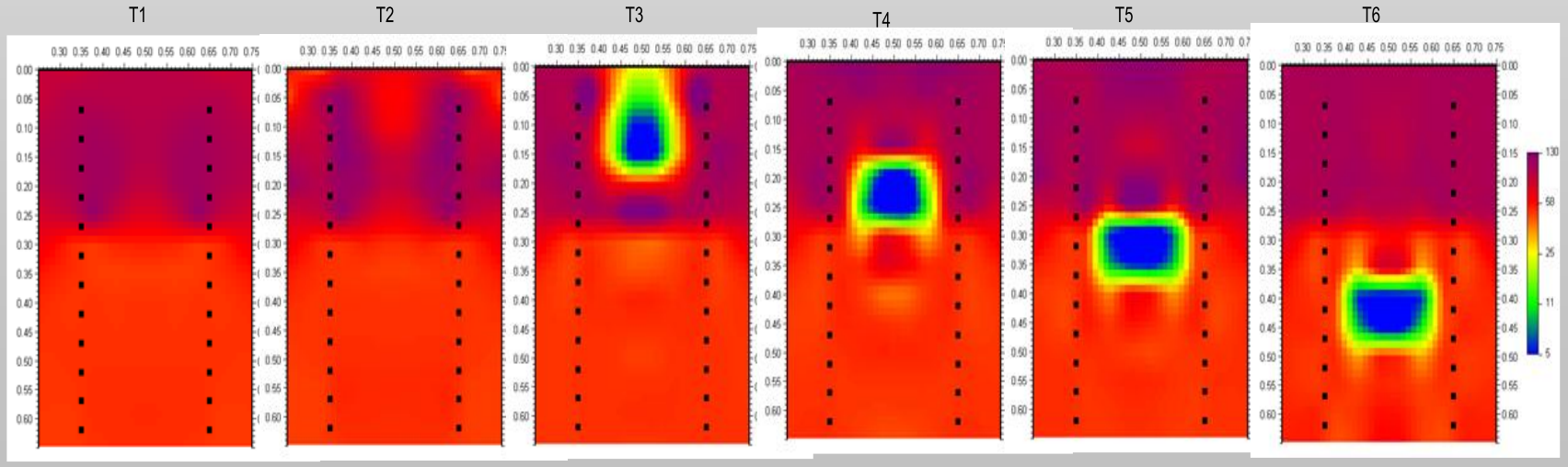


Synthetic Crosshole ERT Modeling

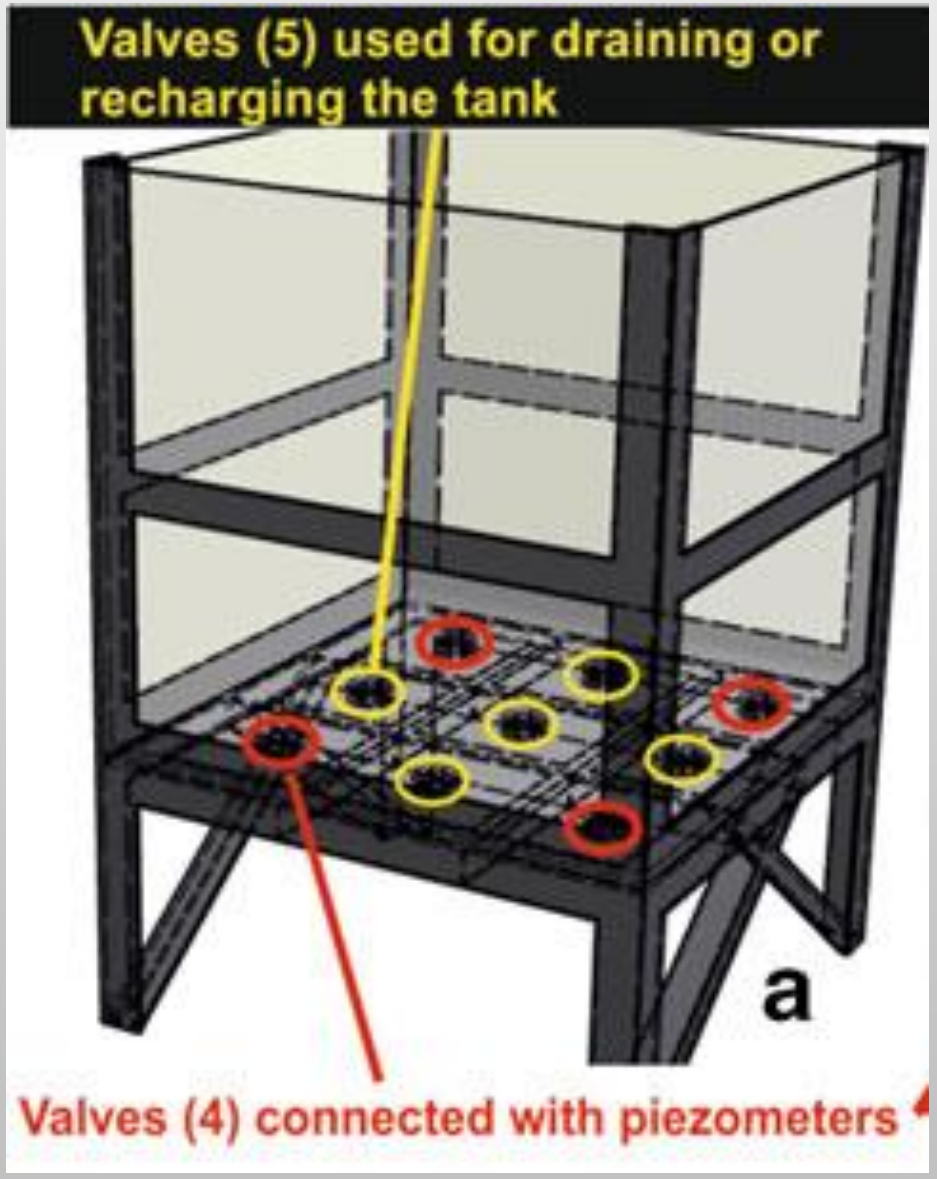
Original Model



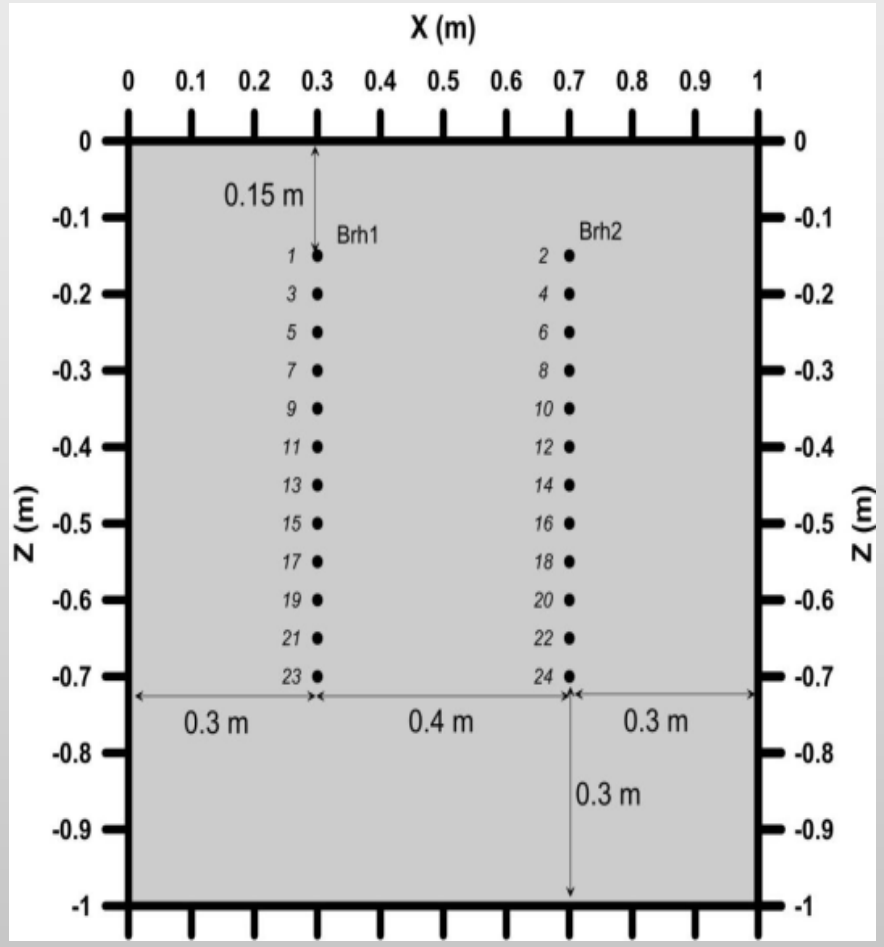
4-D inversion models



Controlled ERT Tank Experiments – First Trials



Controlled ERT Tank Experiments – First Trials



Fine-grained material

Vertical flow of OOMW in an unsaturated-saturated environment

77 crosshole ERT phases every 15min

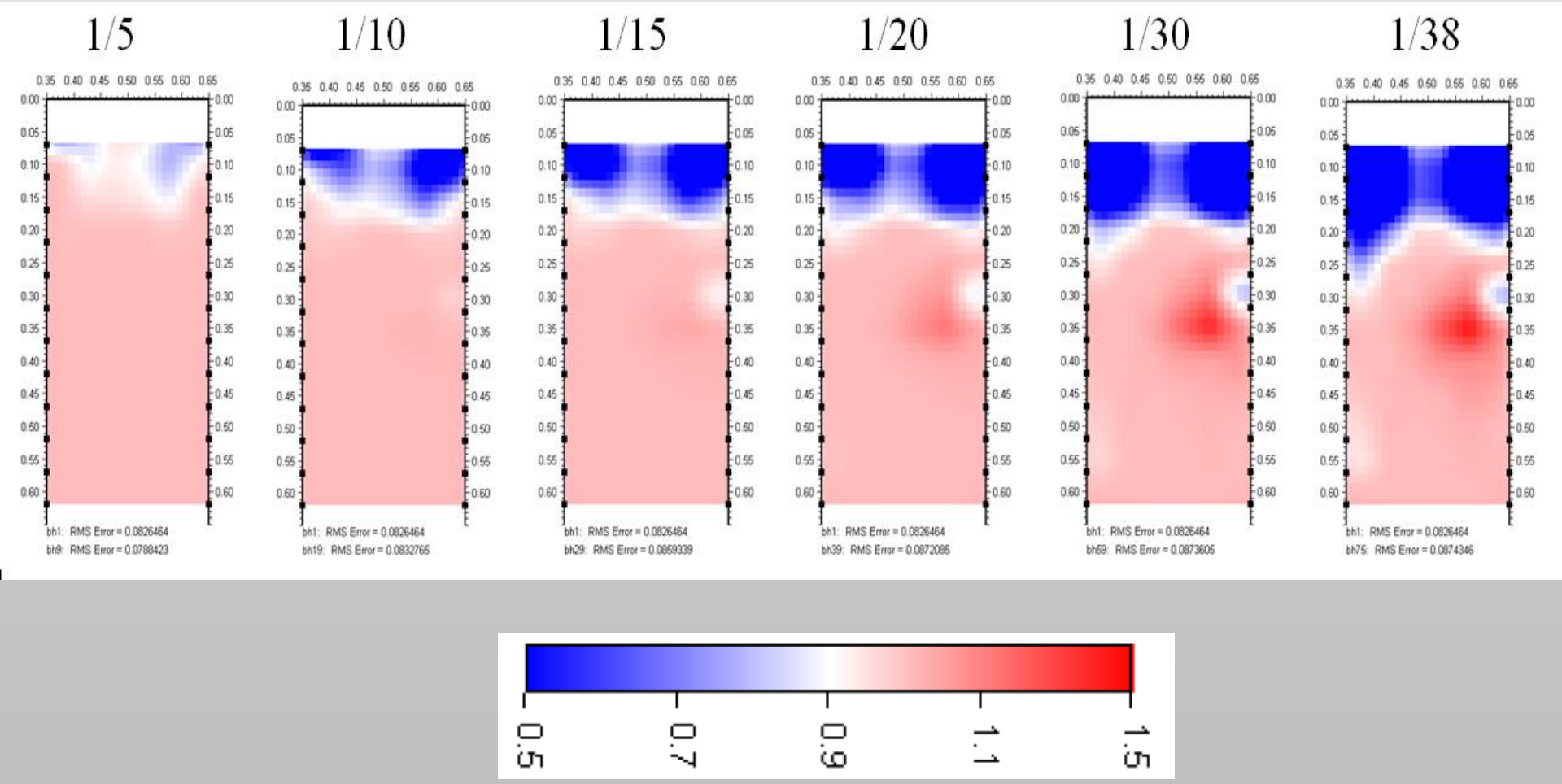
Table 1 Physico–chemical analysis of OOMW sample

Parameter	Value
pH	4.77
DO (dissolved oxygen), mg/L	0.22
EC (electrical conductivity), mS/cm	7.6
Phenols, mg/L	80
COD (chemical oxygen demand), g/L	22.3
Viscosity, mPa.s at 40 °C	93
Density, kg/m^3 at 20 °C	1,004.3

Controlled ERT Tank Experiments – First Trials

4-D inversion

Resistivity ratios



Test Sites for Geophysical Monitoring & Mapping

Methods

ERT

Methods

GPR

Methods

EM

Methods

Seismic

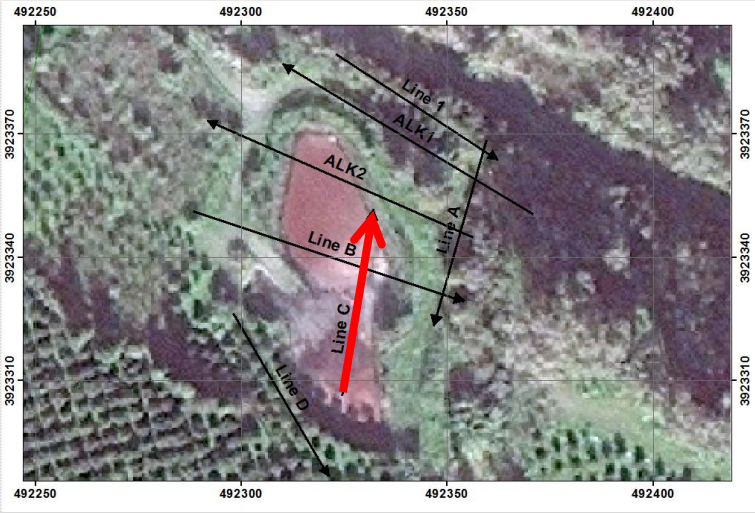
Methods

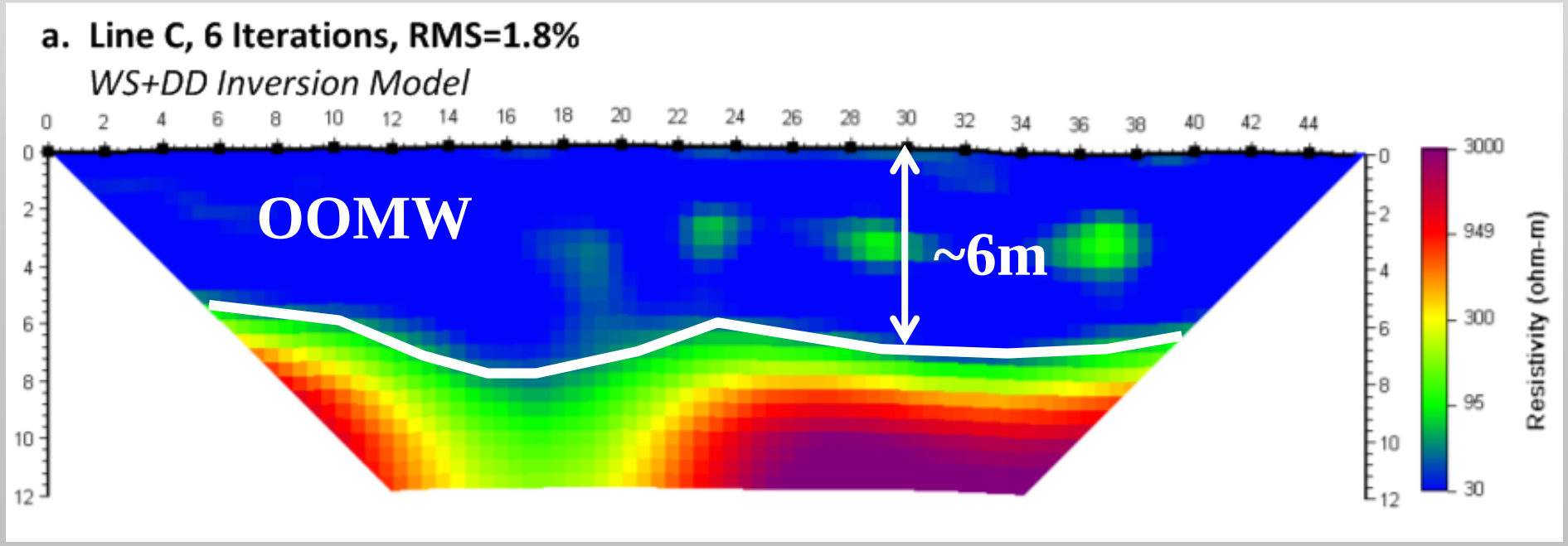
SIP

Methods

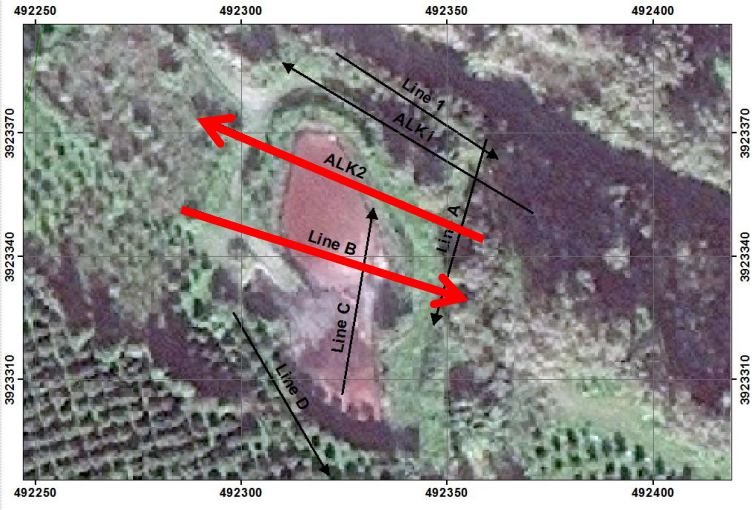
Self Potential

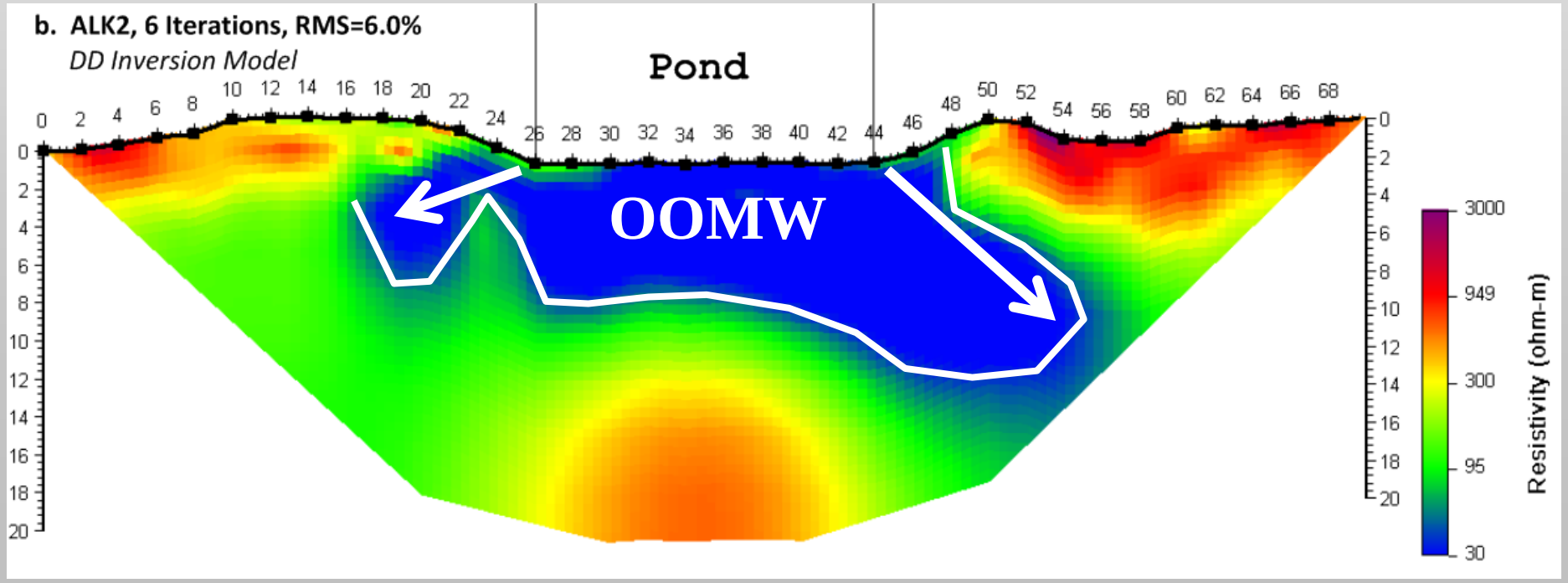
ERT Results – Alikianos: Line C



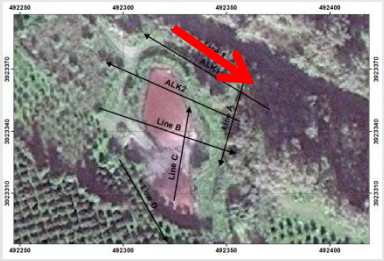


ERT Results – Alikianos: Lines ALK2 & B

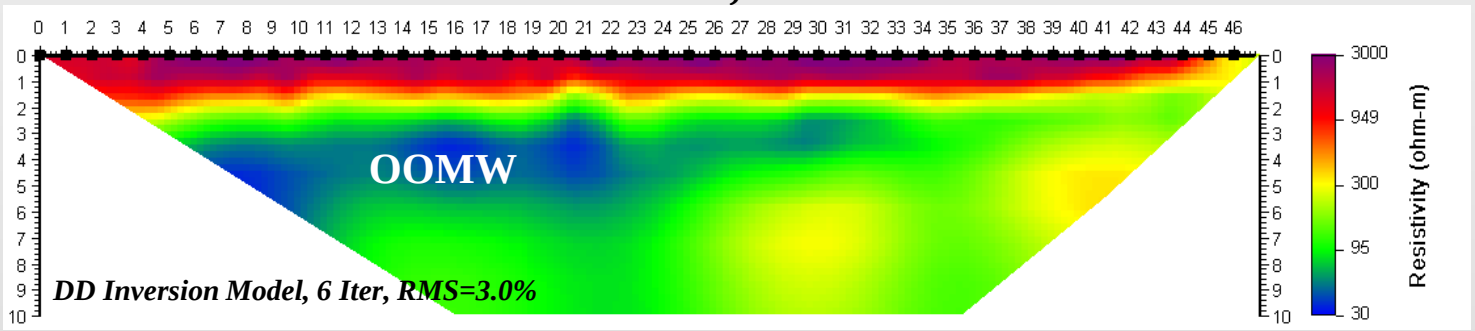




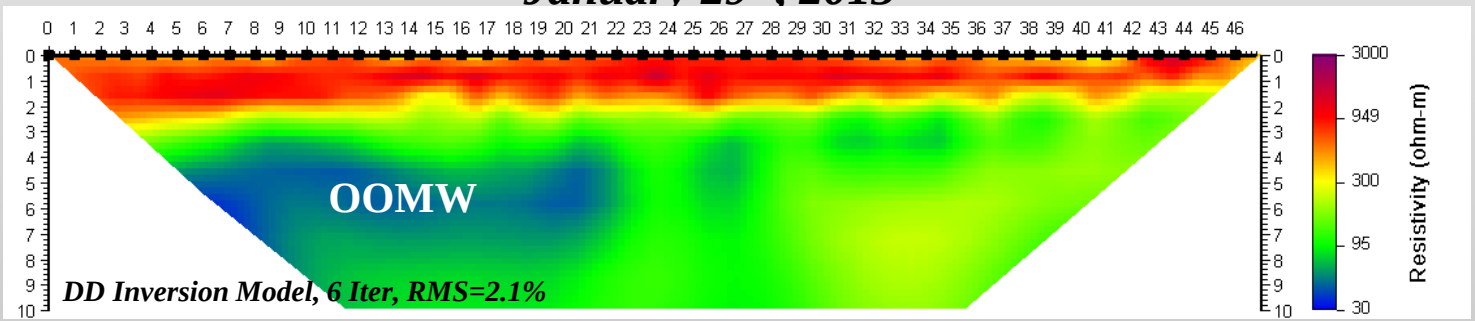
ERT Monitoring Results – Alikianos: Line 1



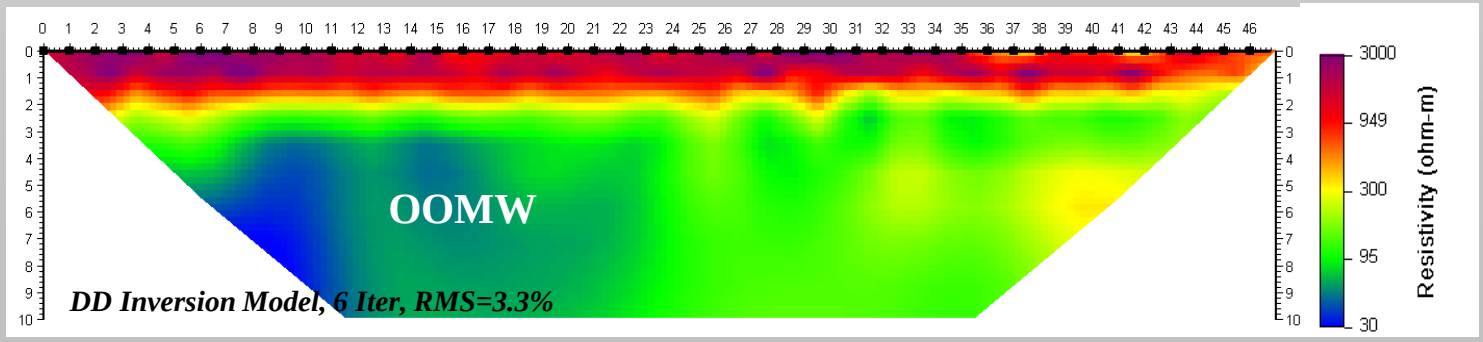
June 8th, 2013



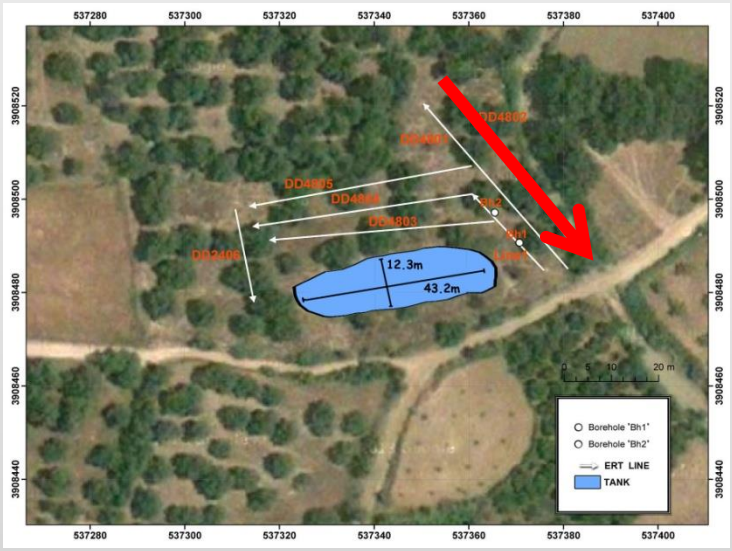
January 29th, 2013

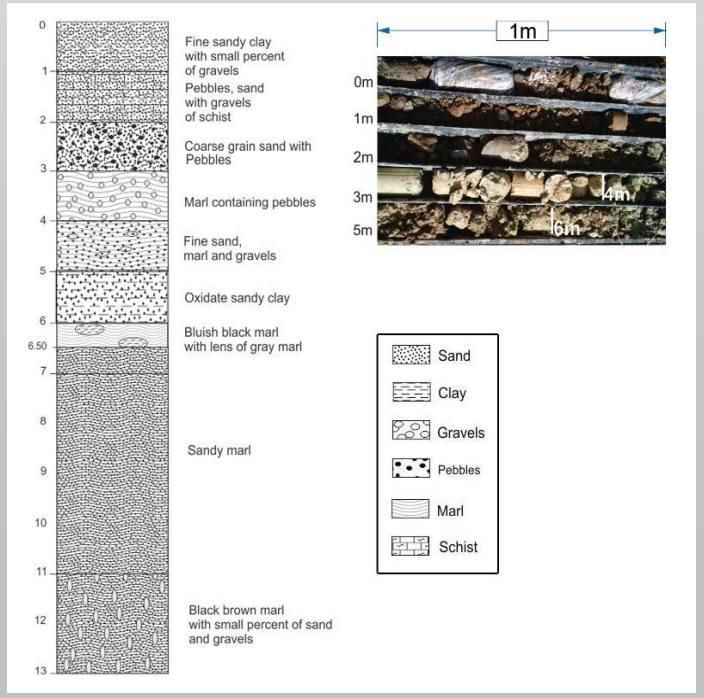


April 30th, 2014

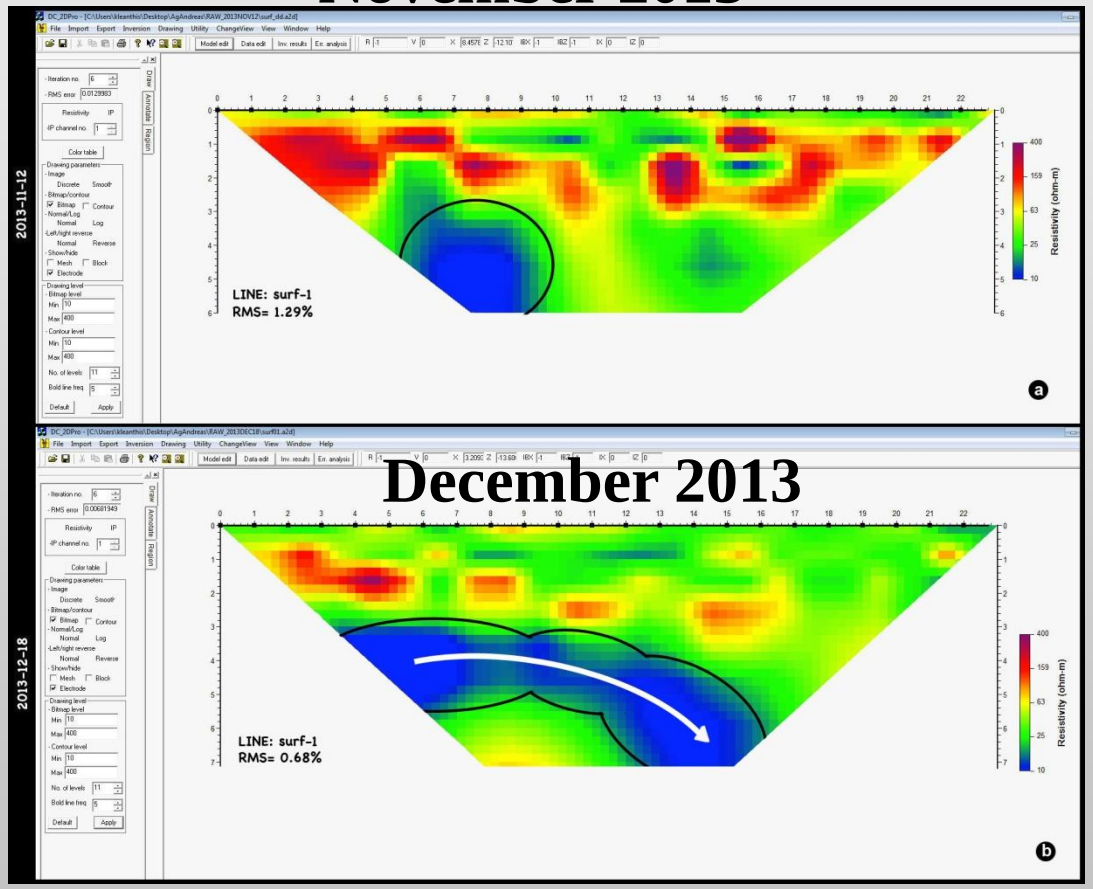


ERT Results – Ag. Andreas: Line 1



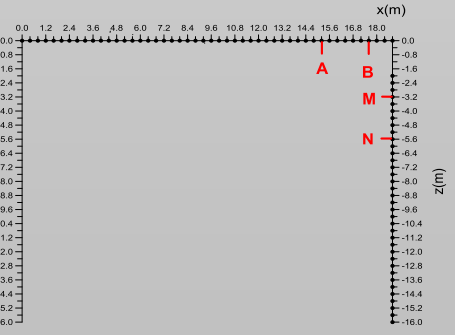


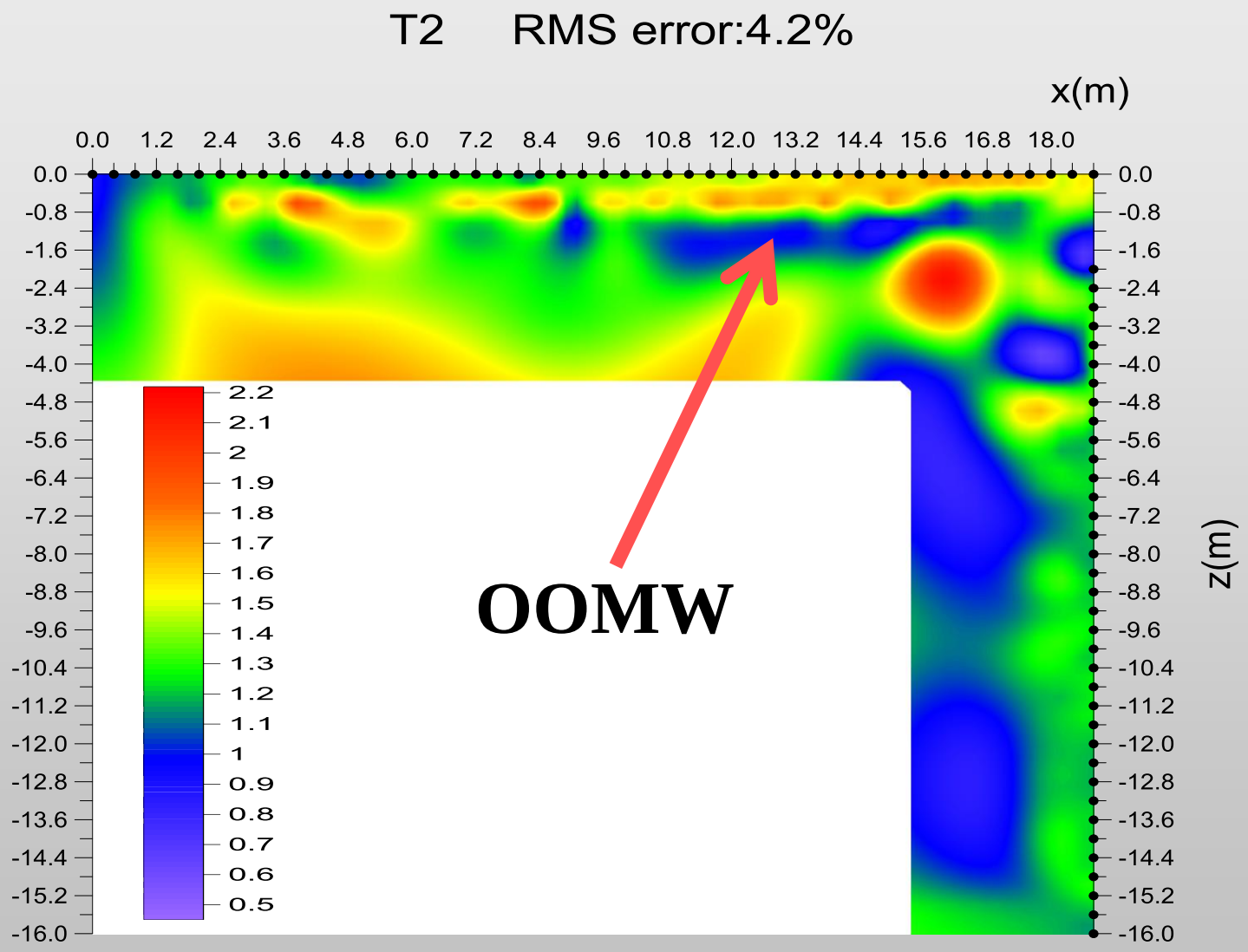
November 2013



December 2013

ERT Results – Roustika: Surface-to-Borehole



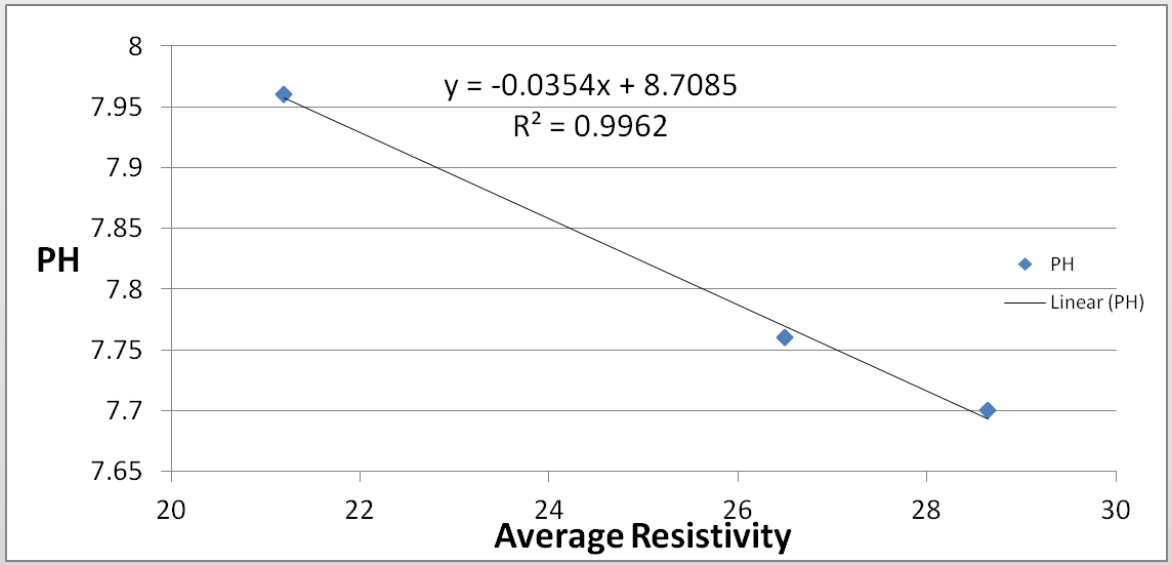


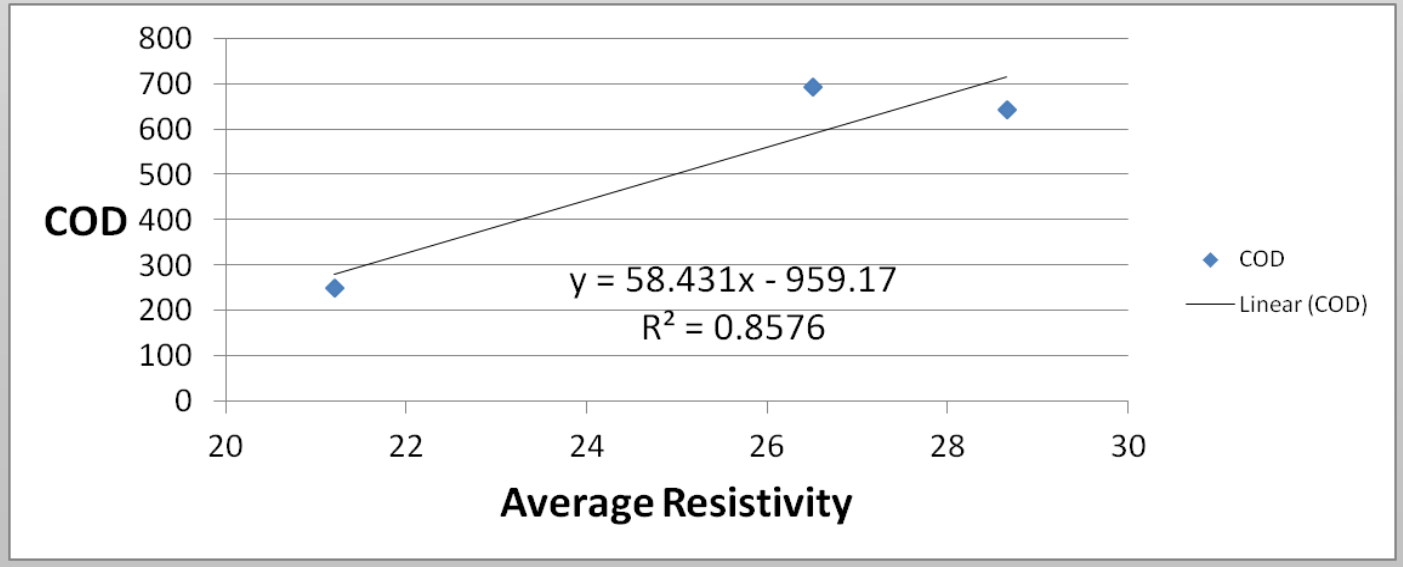
Sampling and Chemical Analysis

Soil Sampling

Correlation geophysical-geochemical parameters

	Febr. 11	Mar. 11	May. 11	July. 11
Г2	7/2/11	16/3/11	11/5/11	19/7/11
Level initial, cm		67	155	165
Level after pumping, cm		72.00	250.00	180.00
pH		7.76	7.70	7.96
EC, µS/cm		1689.00	1550.00	1850.00
EC, S/m		0.17	0.16	0.19
EC, Ohm-m		5.92	6.45	5.41
Phen, mg/L		3.04	2.40	2.56
COD, mg/L		691.67	642.00	250.00
Ni, mg/L		BDL	BDL	BDL
Cu, mg/L		BDL	BDL	BDL
Mn, mg/L		0.90	0.70	0.00
Zn, mg/L		0.07	0.05	0.06
K, mg/L		200.00	48.00	40.00





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Cu, mg/L		BDL	BDL	BDL
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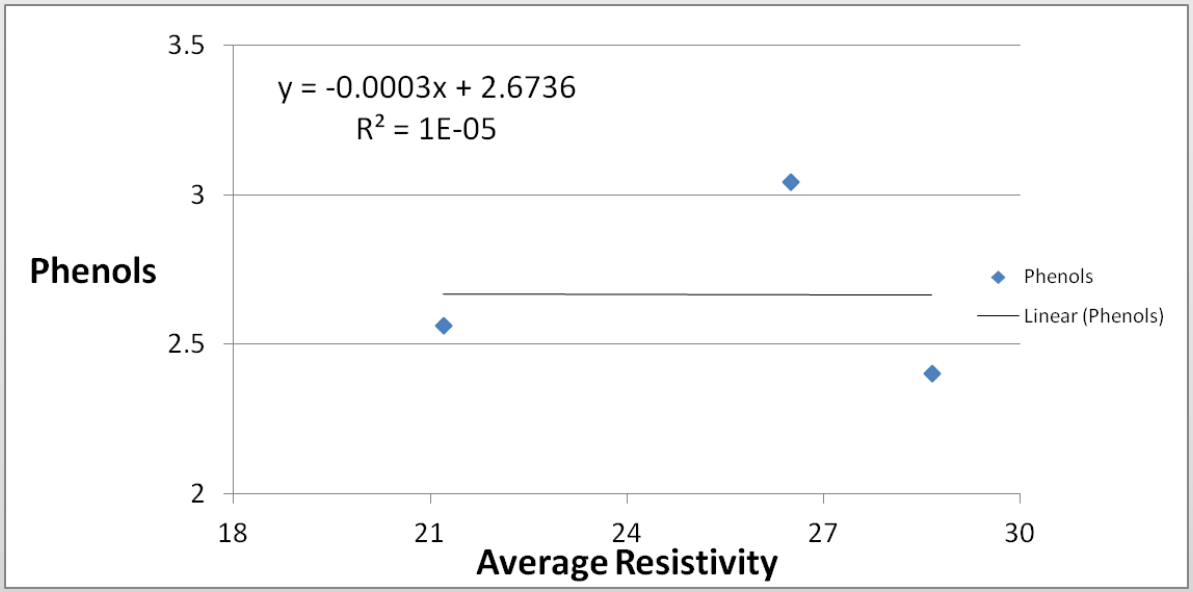
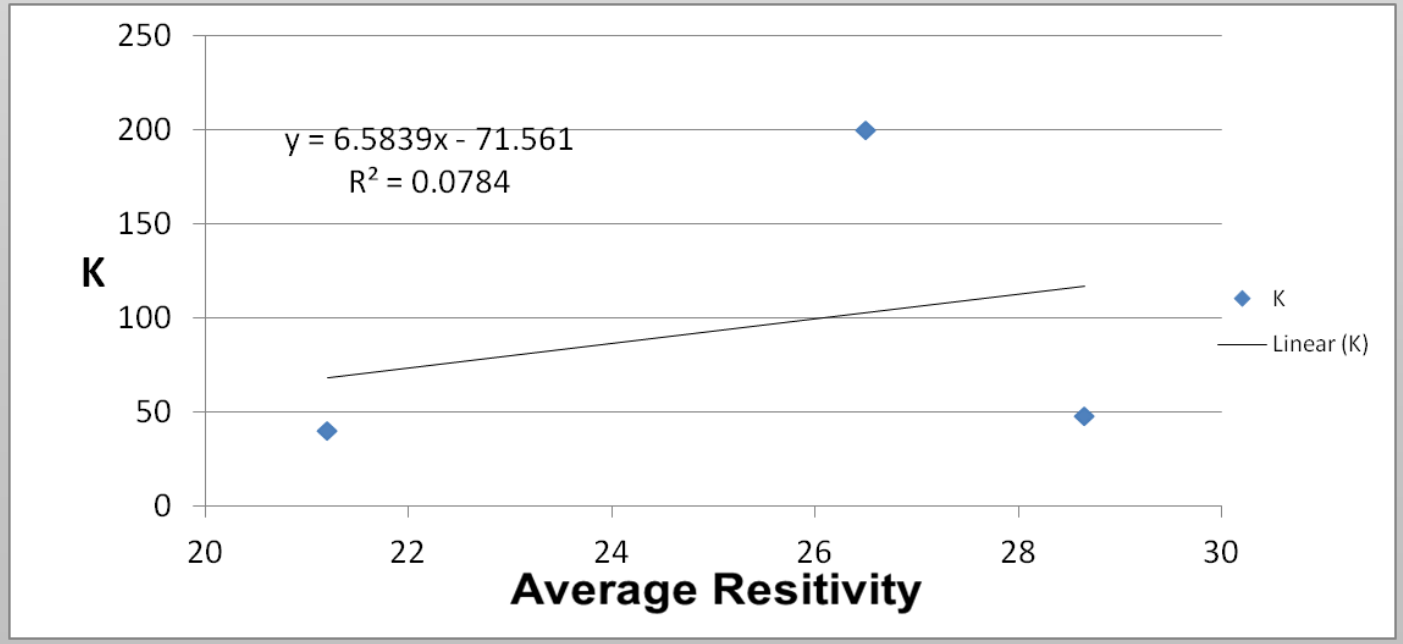
Zn, mg/L		0.07	0.05	0.06
K, mg/L		200.00	48.00	40.00





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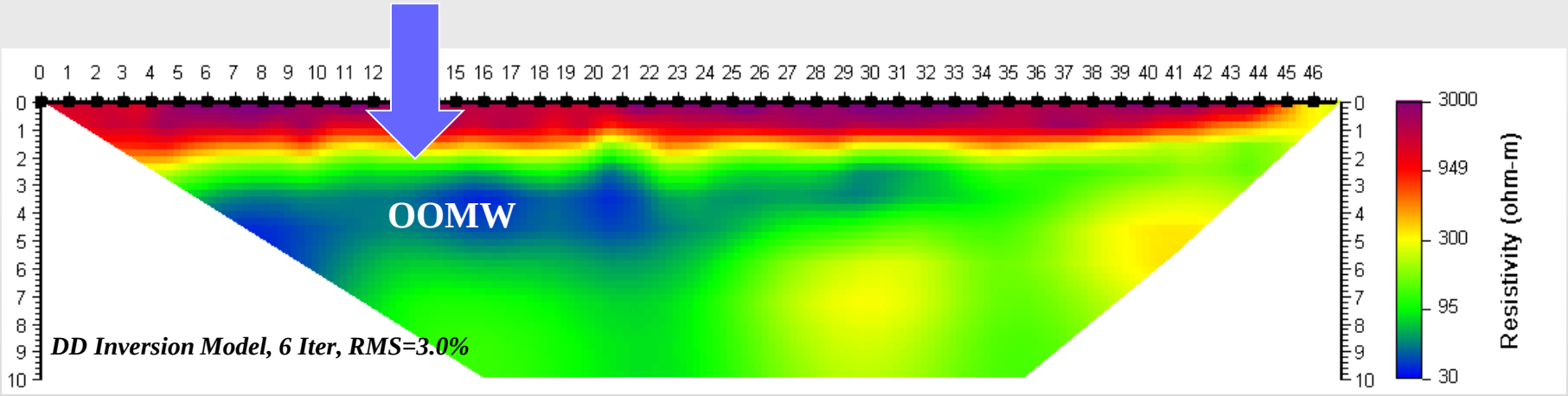

Web based GIS Risk Modeling and Assessment

Firefox

Risk Assessment Modeling Techniques i...

ESRI | IMS-FORTH | Help

Risk Assessment Modeling Techniques in Crete (Rethymno)

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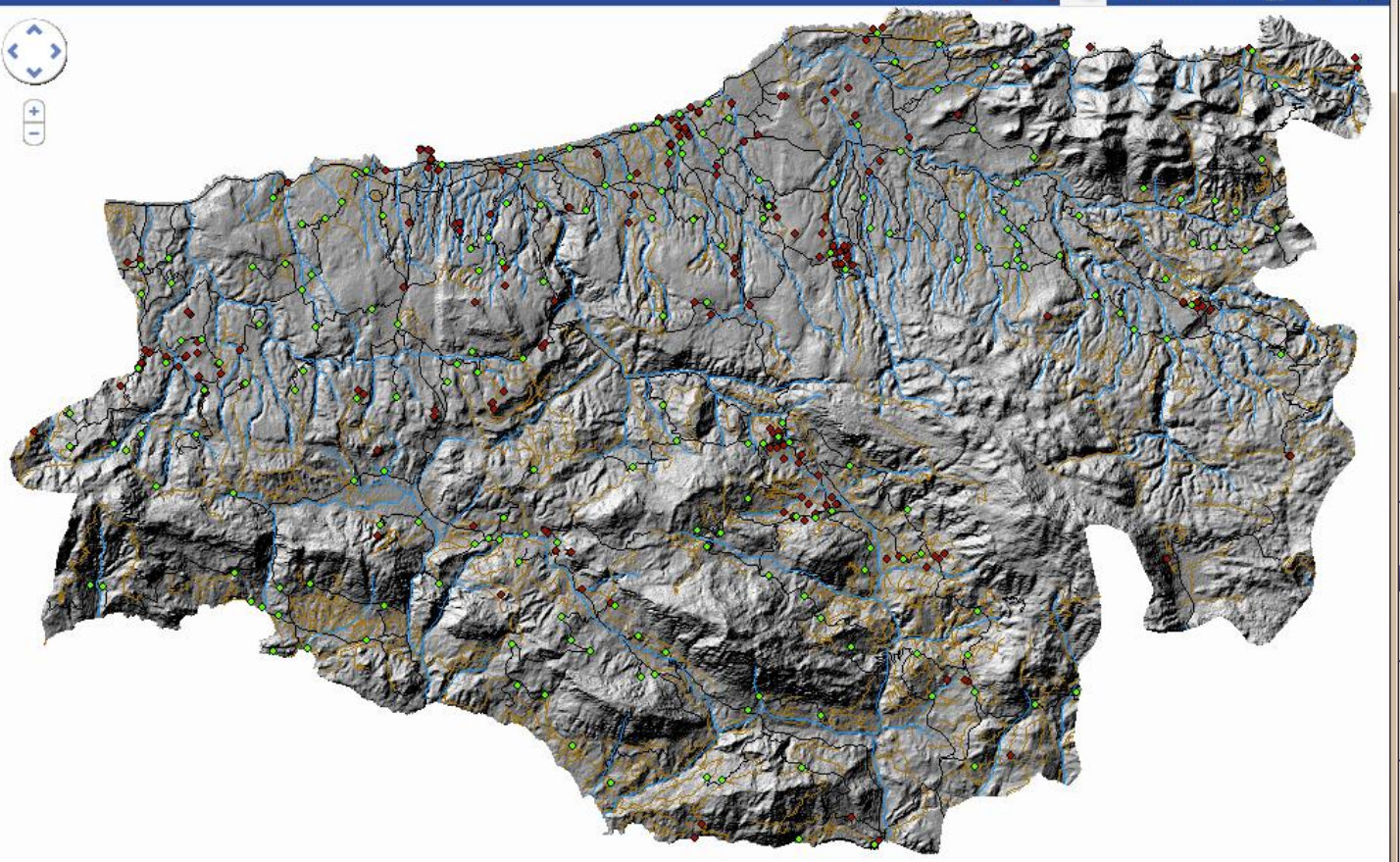
  - Faults
  - Roads Primary
  - Roads Secondary
  - Corine
  - Hydrolithology
  - Geology
  - HillShade
  - Assessment



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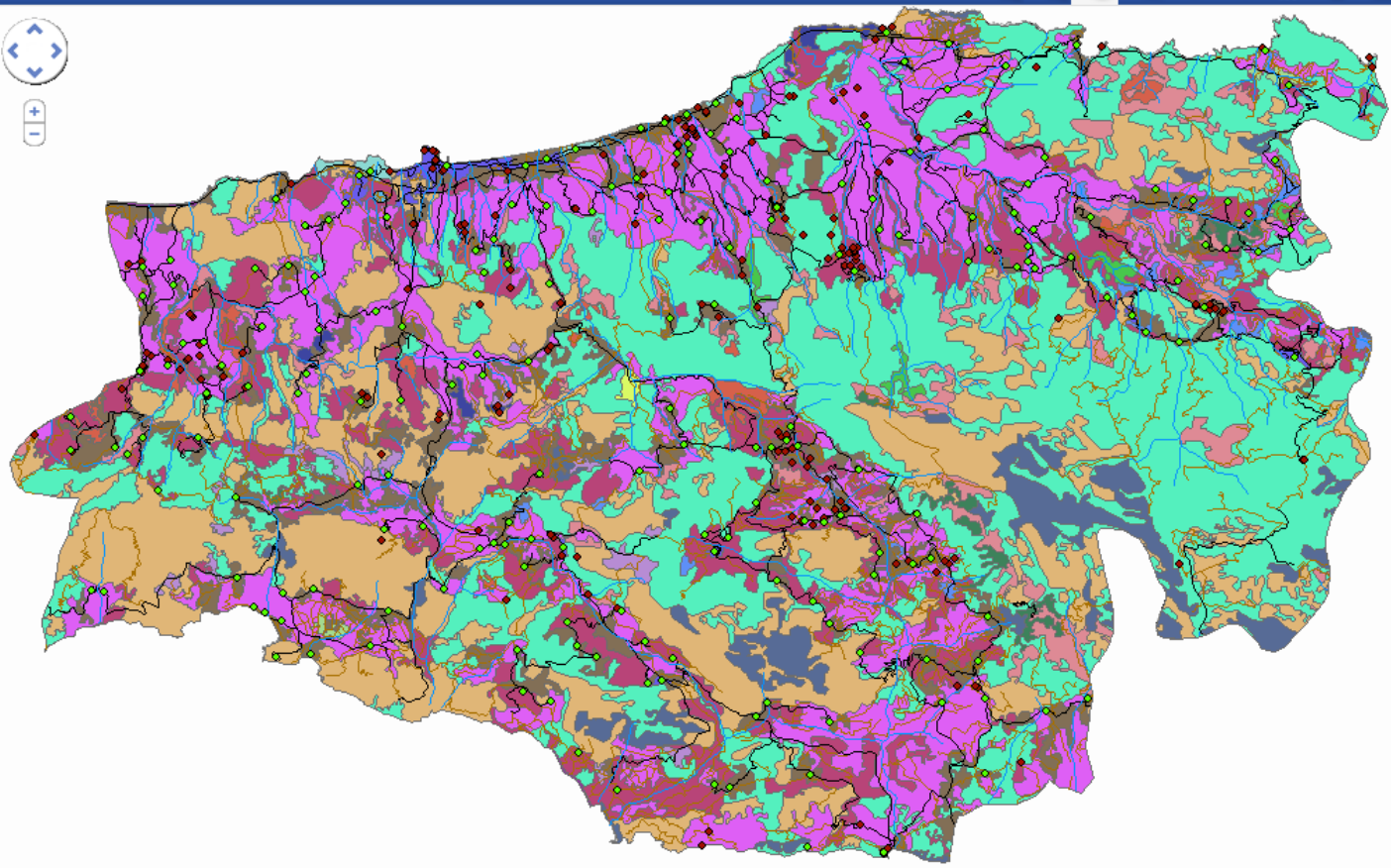
  - Roads Primary
  - Roads Secondary
  - Corine
    - Beaches, dunes, sands
    - Broad-leaved forest
    - Complex cultivation patterns
    - Coniferous forest
    - Discontinuous urban fabric
    - Fruit trees and berry plantations
    - Industrial or commercial units
    - Land principally occupied by agricult
    - Mineral extraction sites
    - Mixed forest
    - Natural grasslands
    - Non-irrigated arable land
    - Olive groves
    - Pastures
    - Port areas
    - Sclerophyllous vegetation
    - Sparsely vegetated areas
    - Sport and leisure facilities
    - Transitional woodland-shrub
    - Vineyards
  - Hydrolithology



Firefox

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  - CoastLine
  - Faults
  - Roads Primary
  - Roads Secondary
  - Corine
  - Hydrolithology
    - Granular mainly alluvial deposits of var
    - Granular non-alluvial deposits of low to
    - Karstic formations of high to moderate p
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    - Practically impermeable formations of lc
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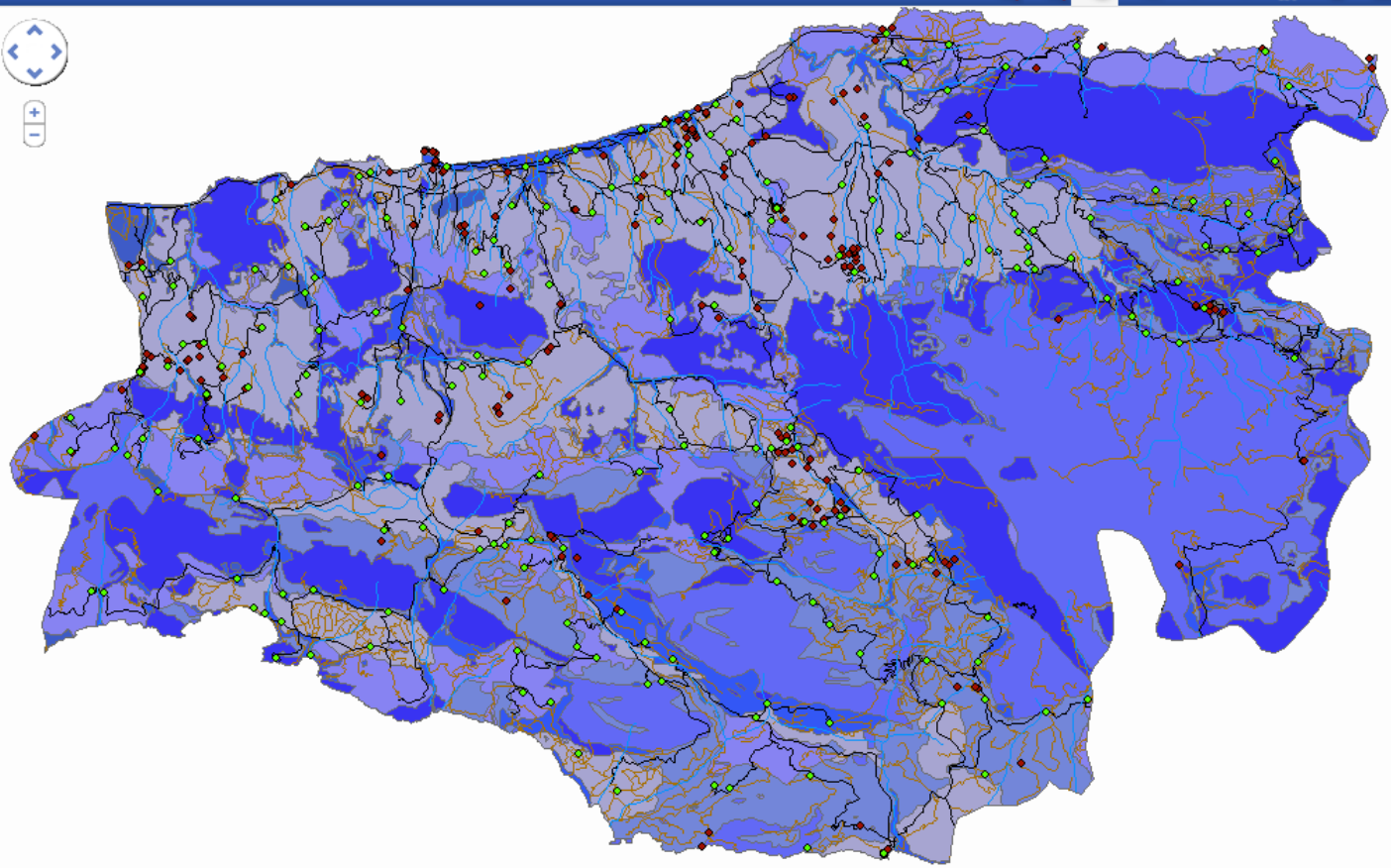
  - Geology
  - HillShade
  - Assessment



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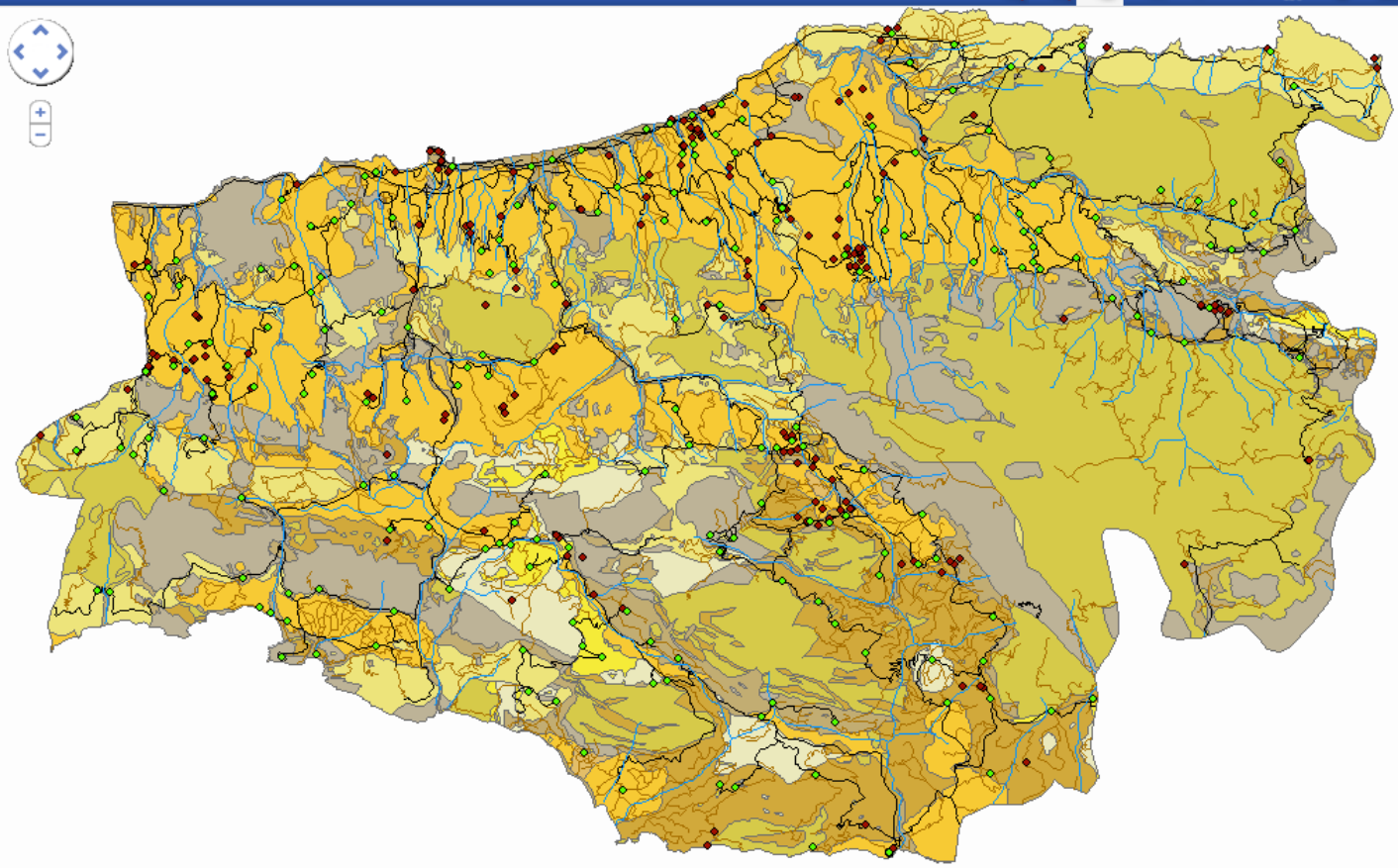
  - Roads Secondary
  - Corine
  - Hydrolithology
  - Geology
    - Alluvial
    - Deposits
    - Dolomites
    - Flysch
    - Gneiss
    - Limestones
    - Marls-Marly limestones
    - Metamorphic rocks
    - Ophiolites
  - HillShade
  - Assessment



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  - Faults
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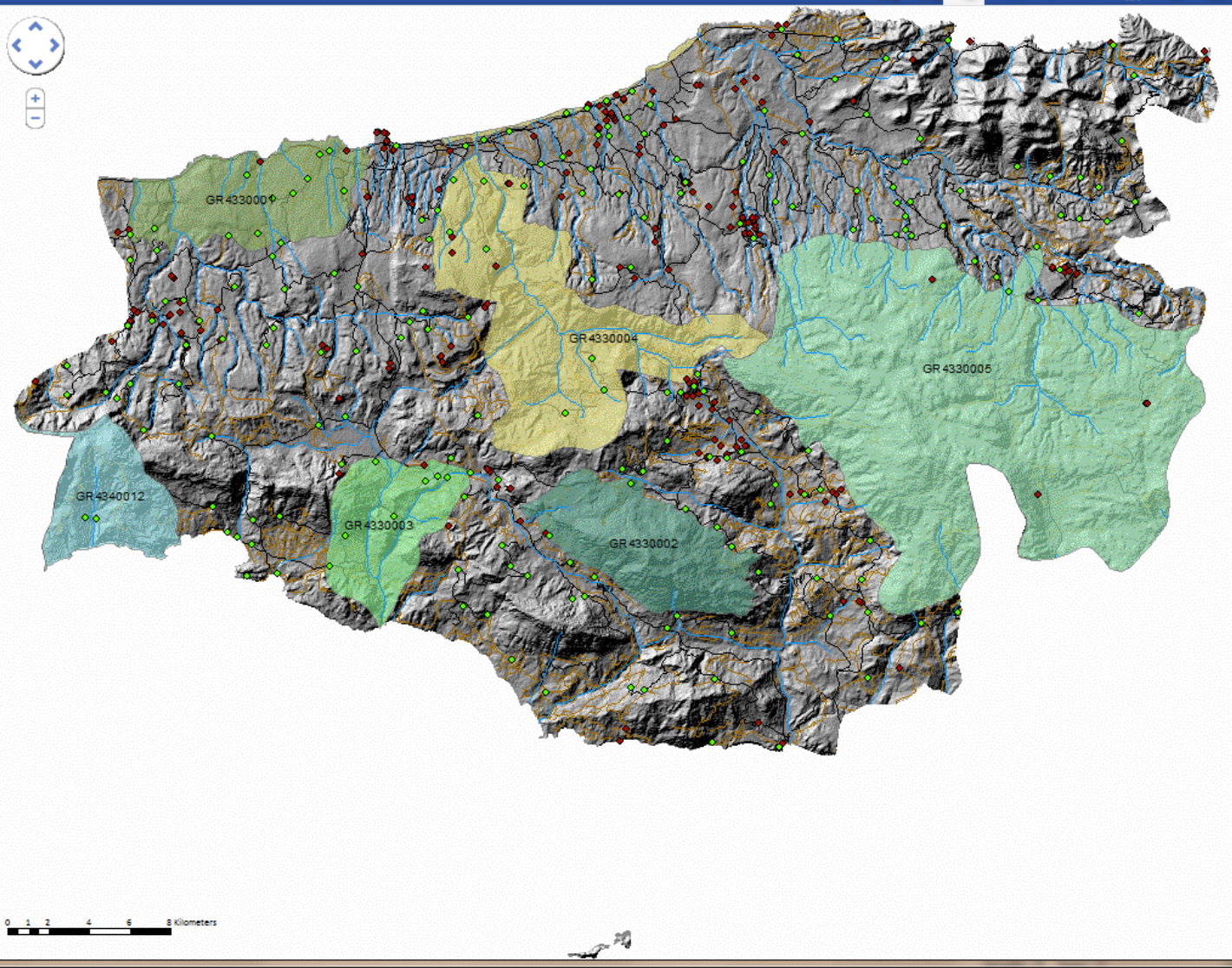
  - Assessment



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Risk Assessment Modeling Techniques in Crete (Rethymno)

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  - Hydrolithology
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  - HillShade
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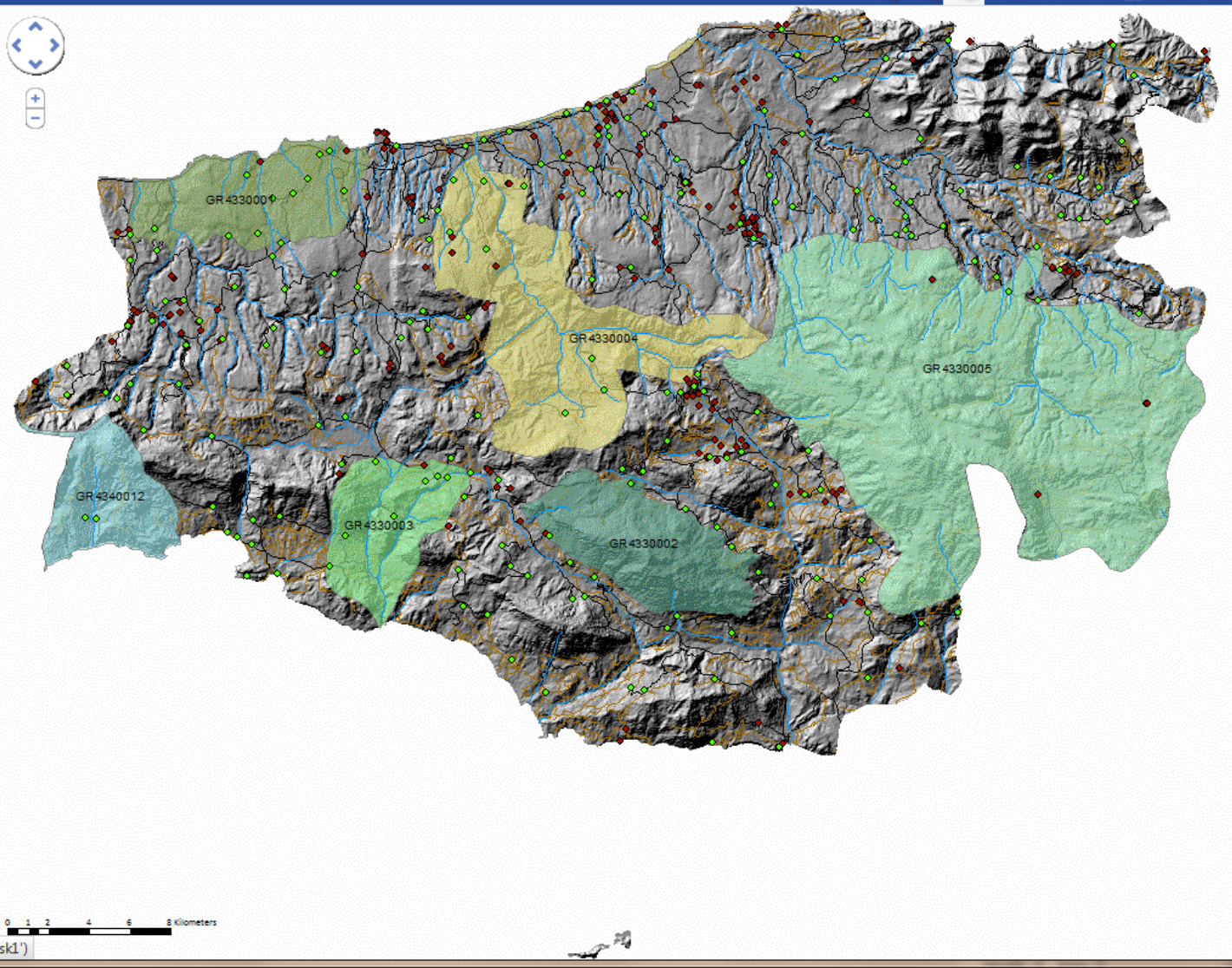

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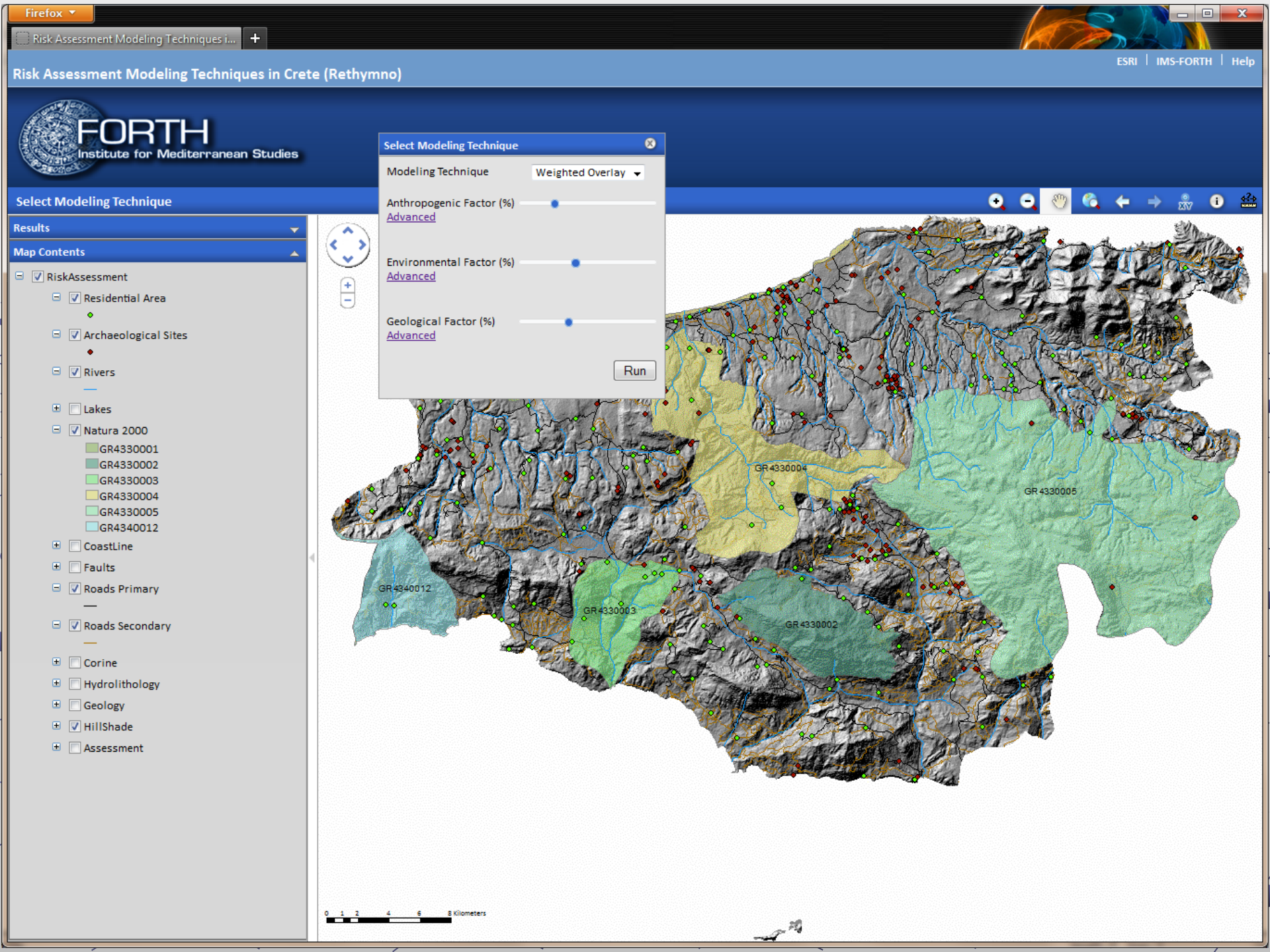
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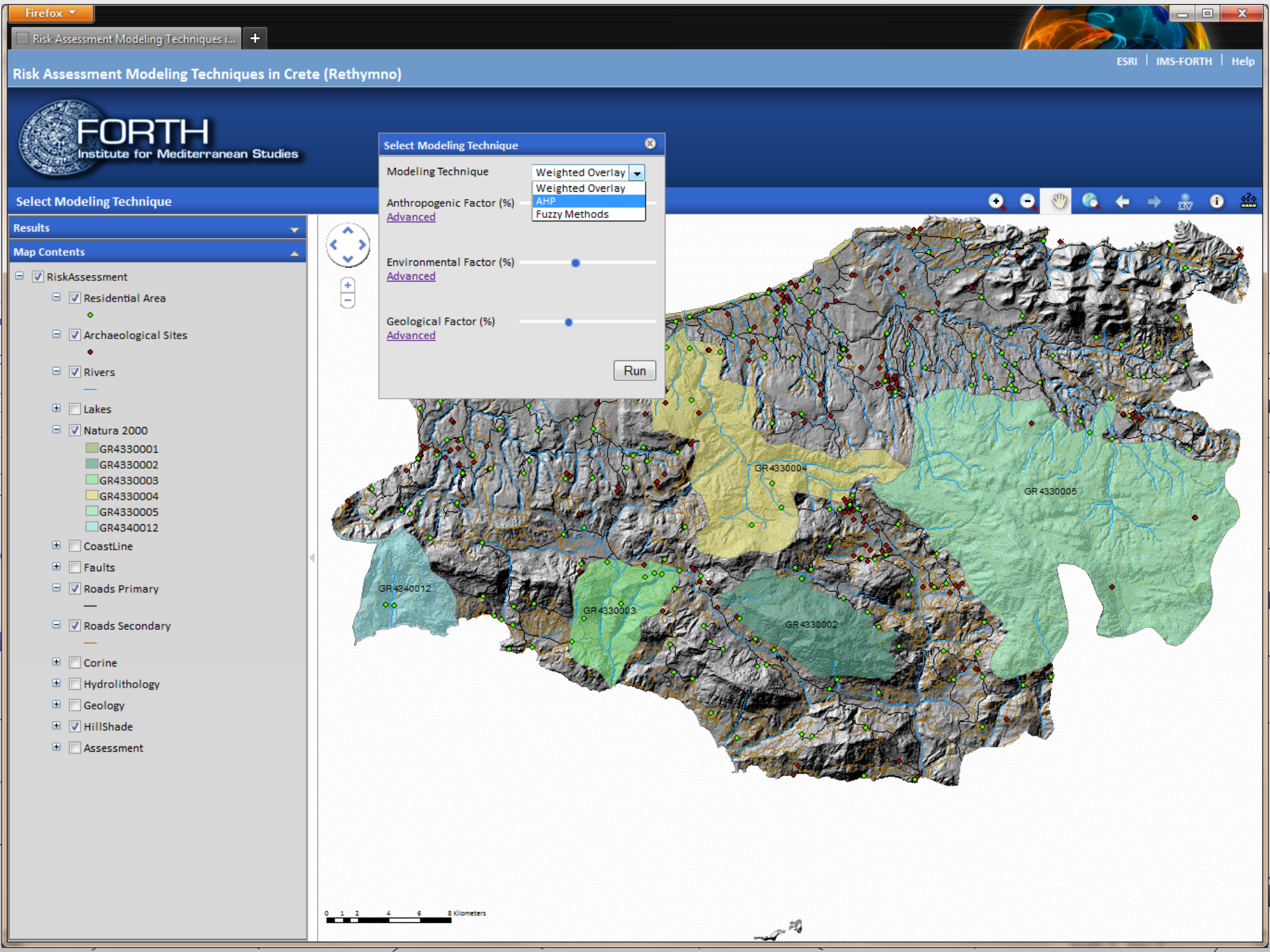
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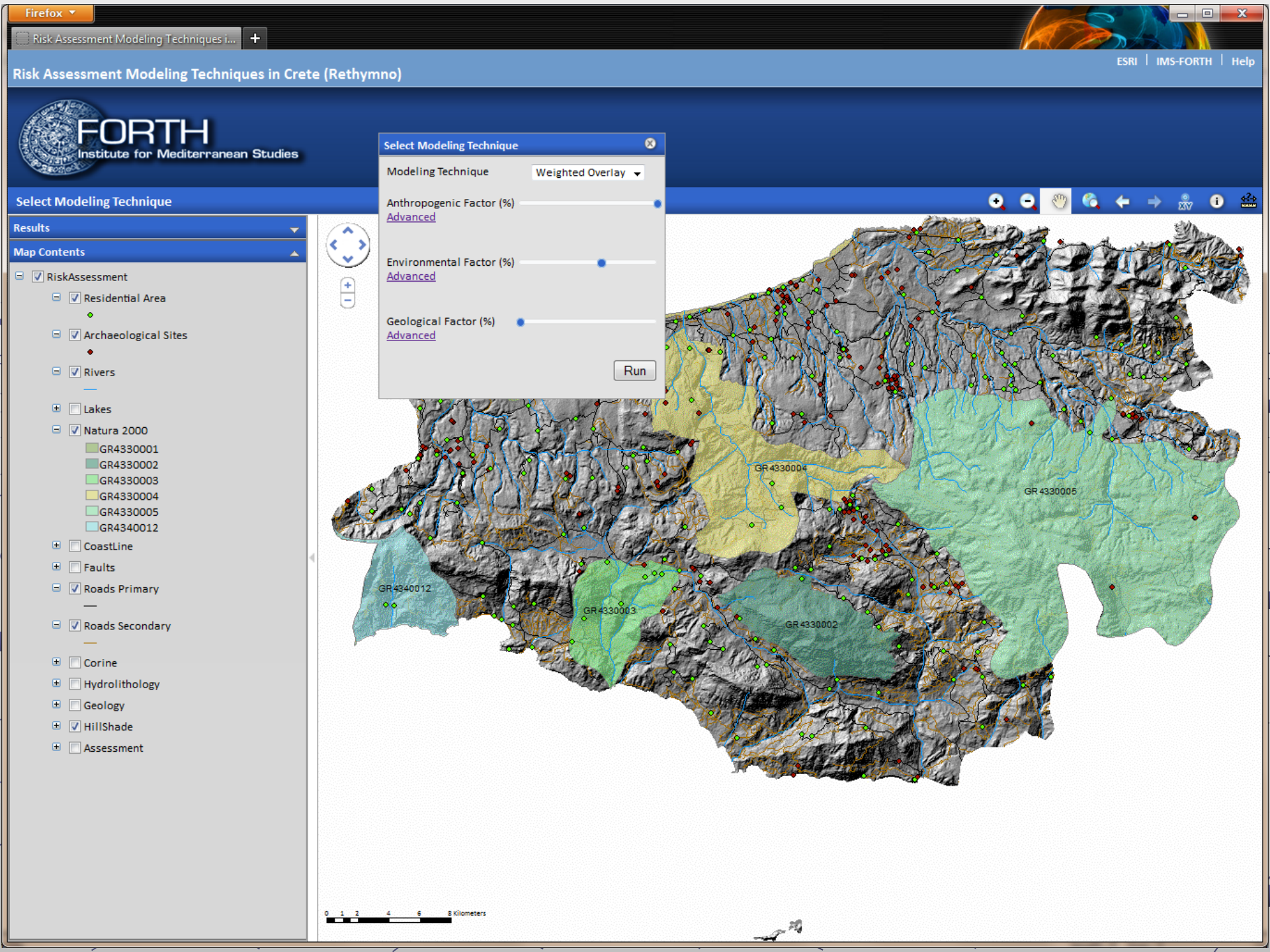
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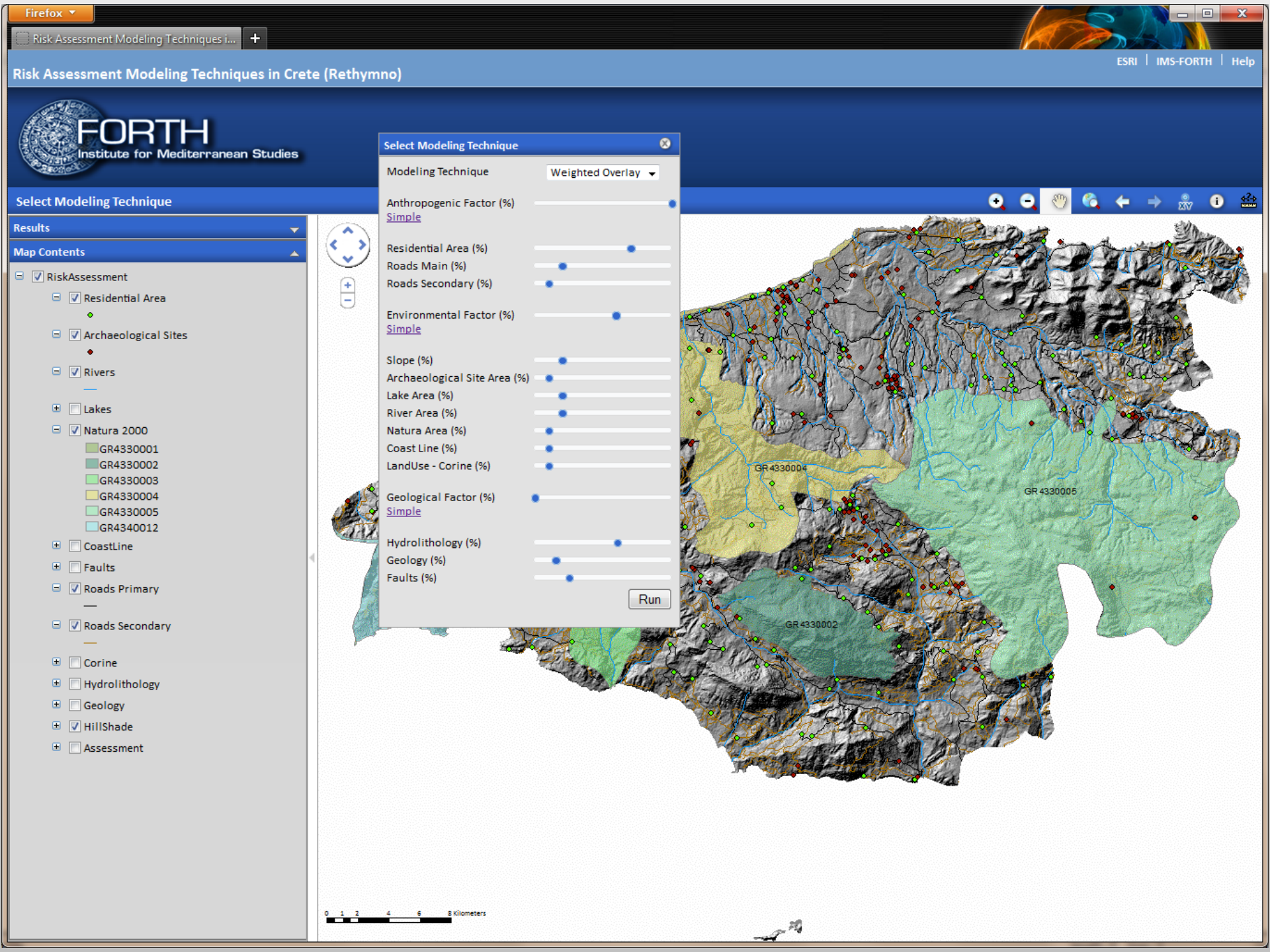
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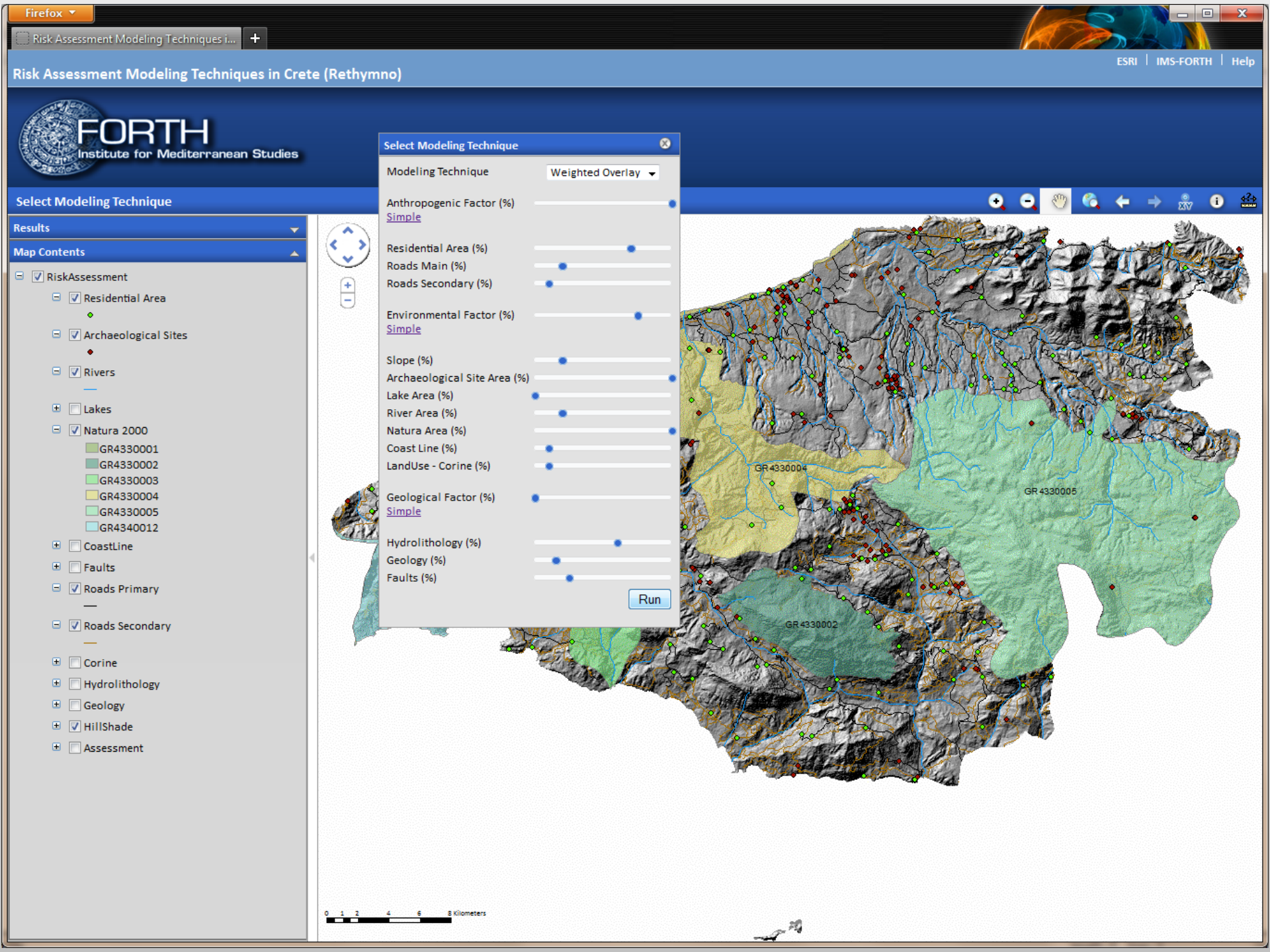
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Risk Assessment Modeling Techniques in Crete (Rethymno)

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Institute for Mediterranean Studies

Select Modeling Technique

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Clear All

Submitted Select Modeling Technique Cancel

Map Contents

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  - Roads Primary
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  - Hydrolithology
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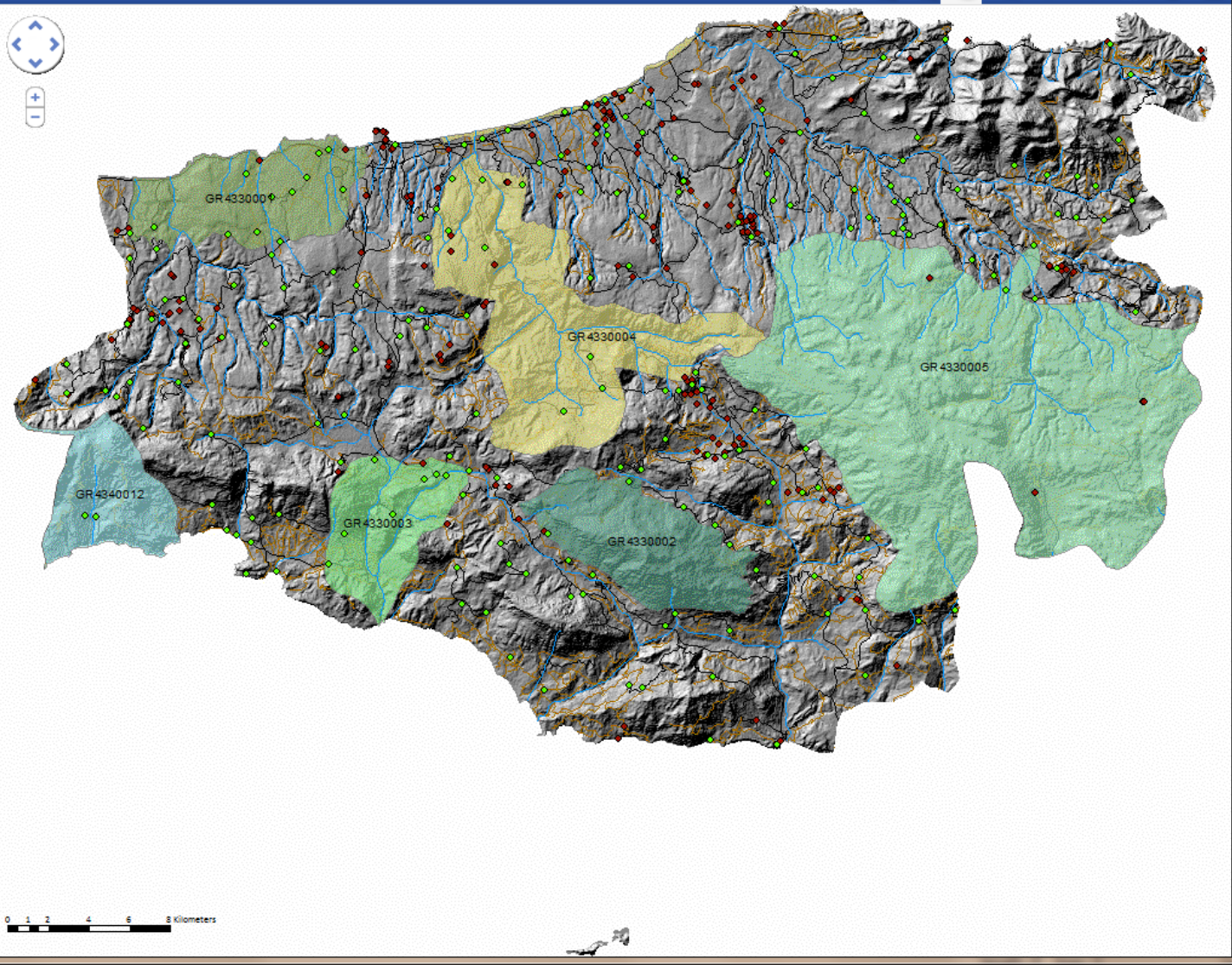

Firefox

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Risk Assessment Modeling Techniques in Crete (Rethymno)

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Select Modeling Technique

Results

Clear All

Executing Select Modeling Technique Cancel

Inputs

Messages

Submitted.
Executing...
Executing (Assessment): Assessment WO 57 70 2
Start Time: Fri Aug 17 15:03:12 2012

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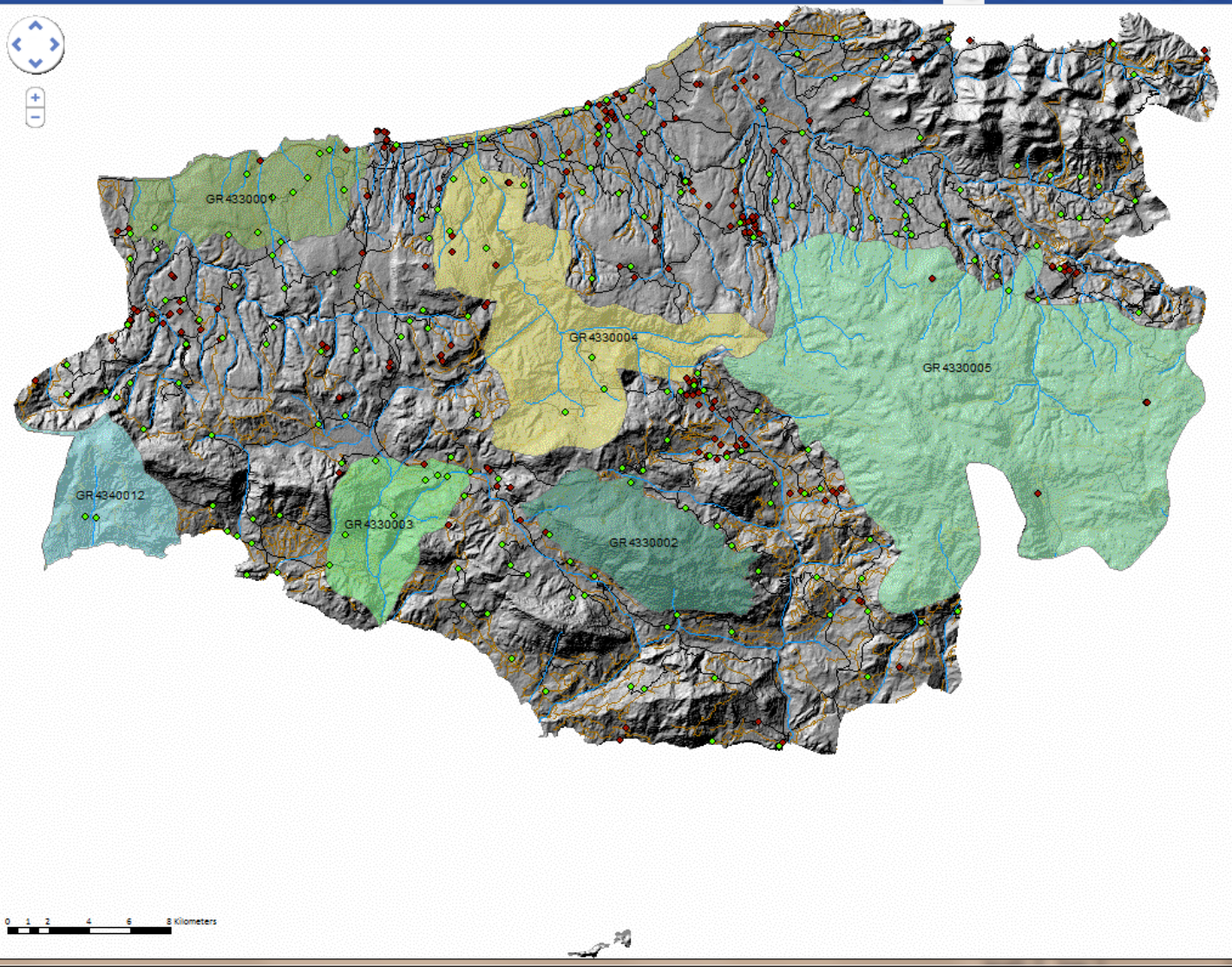

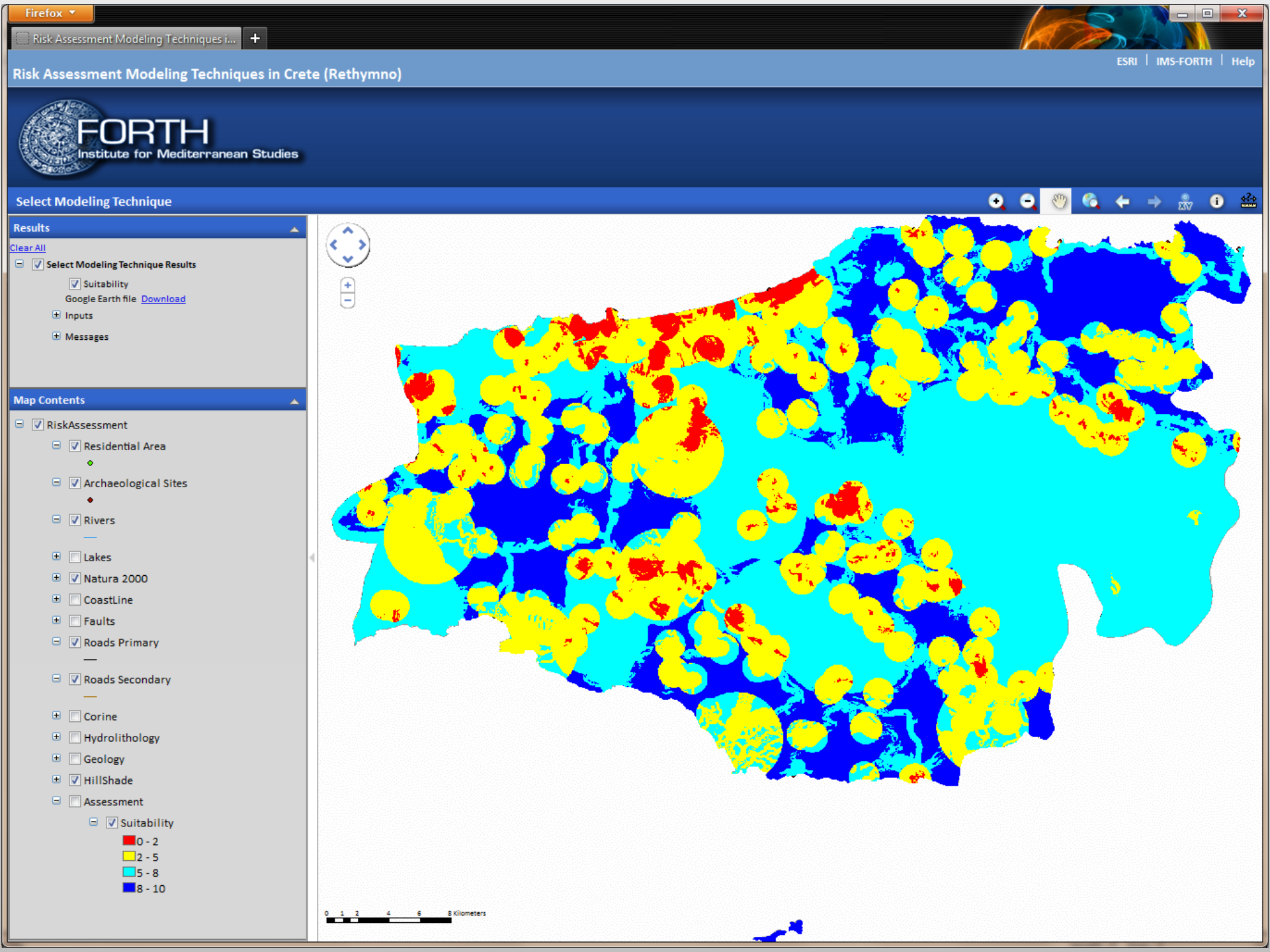
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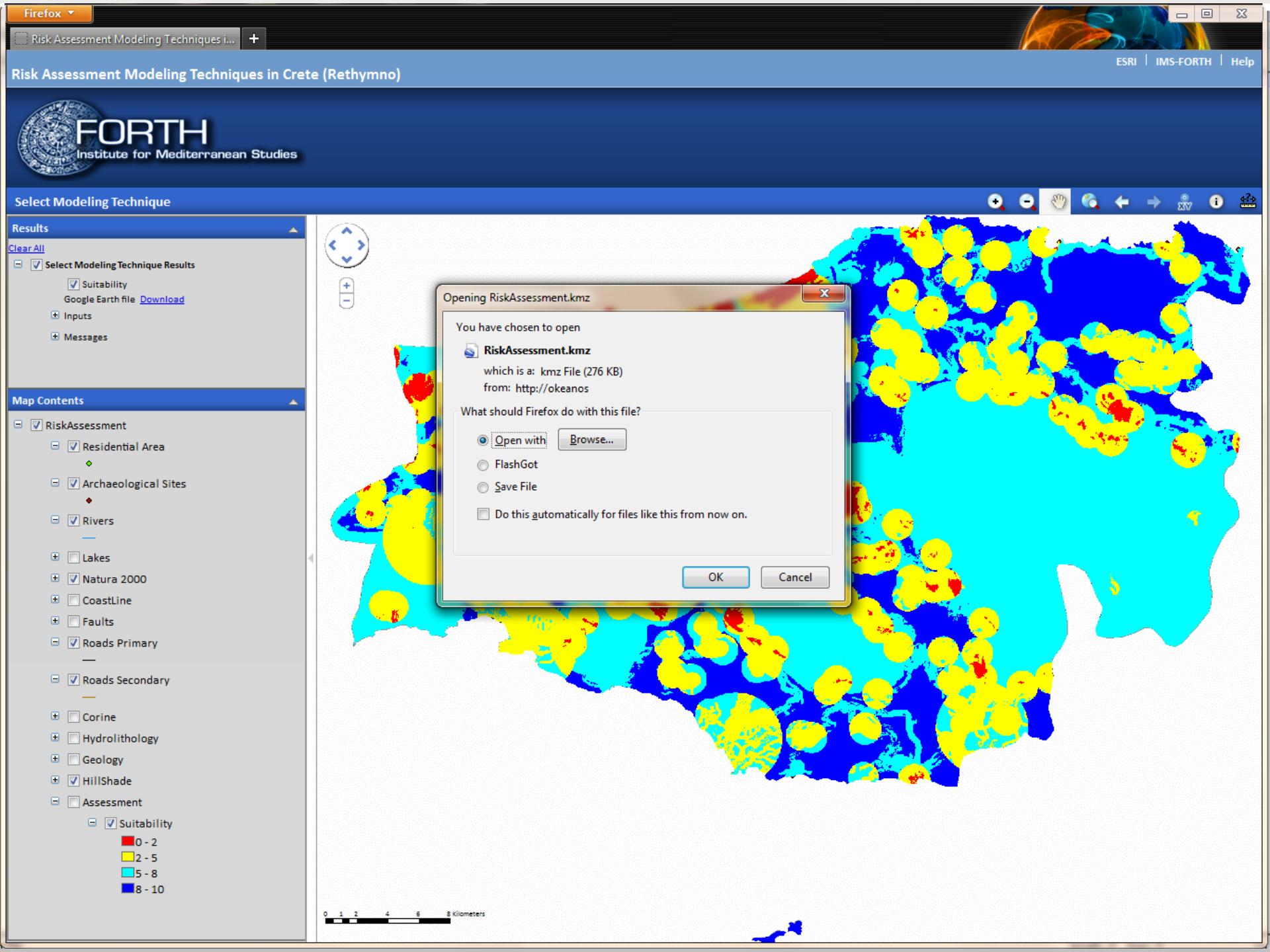
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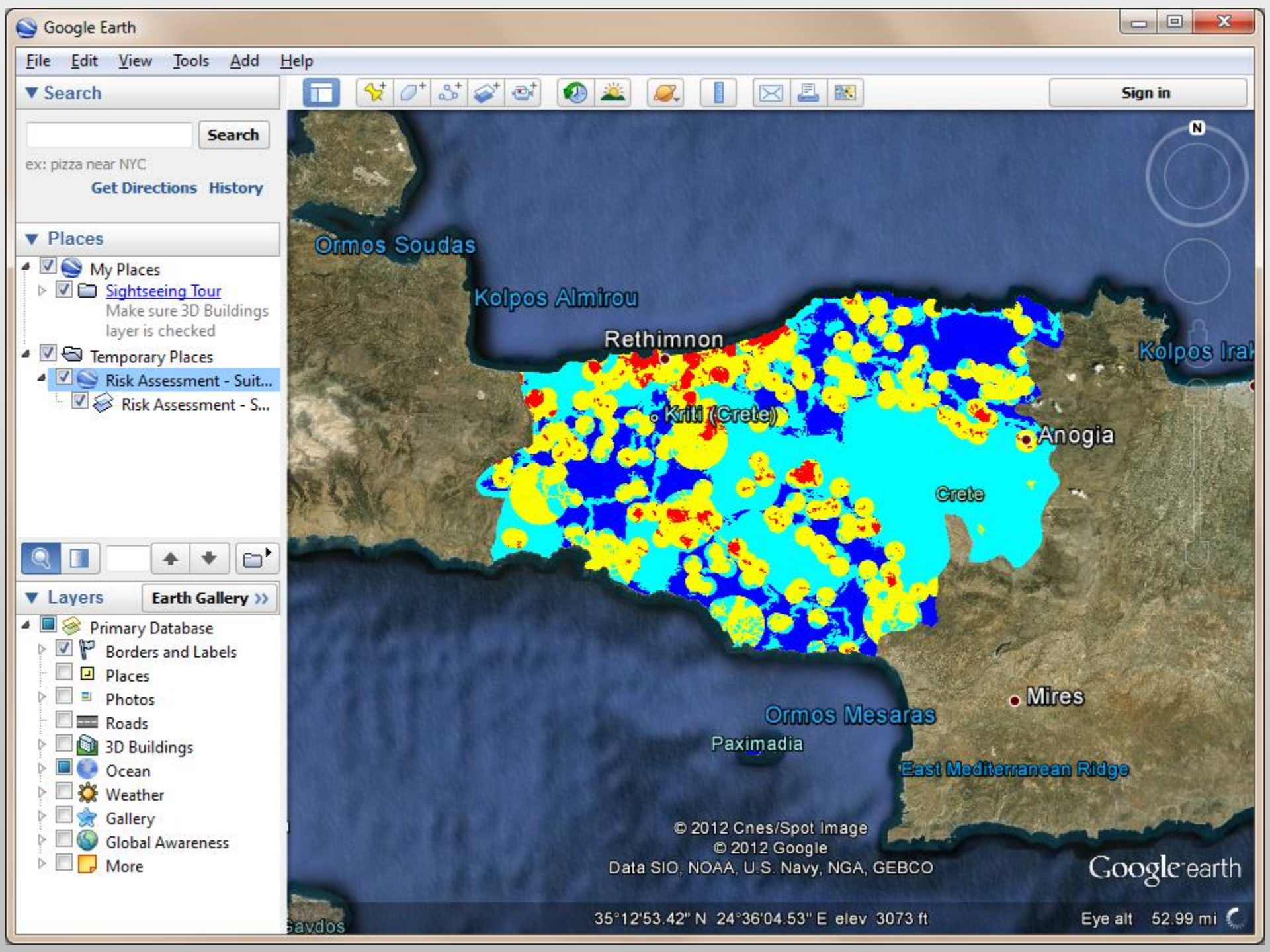
Google Earth
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ex: pizza near NYC
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Places
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Sightseeing Tour
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Ormos Soudas
Kolpos Almirou
Rethimnon
Kriti (Crete)
Anogia
Crete
Mires
Ormos Mesaras
Paximadia
East Mediterranean Ridge
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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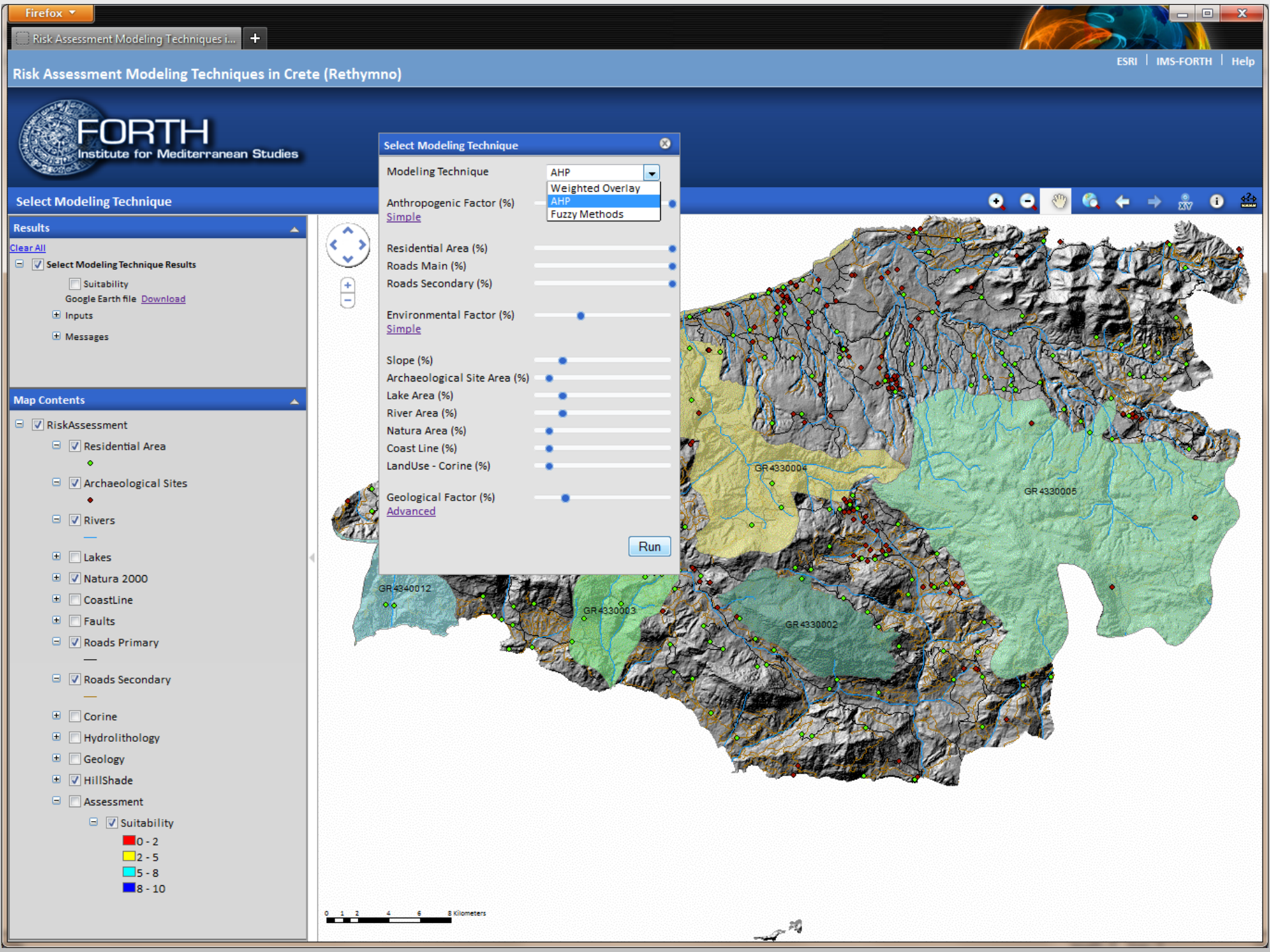
35°12'53.42" N 24°36'04.53" E elev 3073 ft
Eye alt 52.99 mi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  - Messages
- Select Modeling Technique Results
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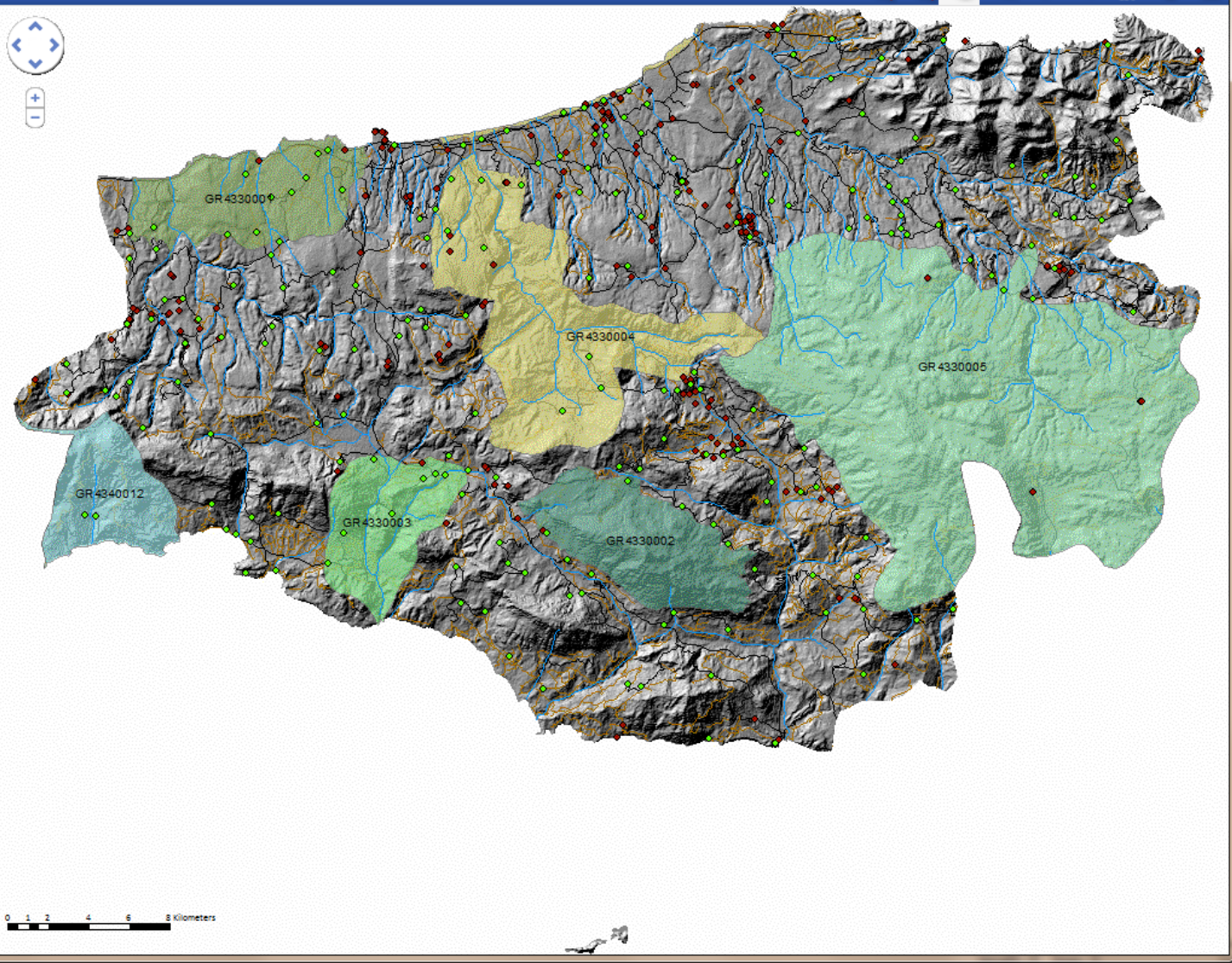

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Risk Assessment Modeling Techniques i...

ESRI | IMS-FORTH | Help

Risk Assessment Modeling Techniques in Crete (Rethymno)

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Select Modeling Technique

Results

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Inputs

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Roads Main (%): 33
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- RiskAssessment
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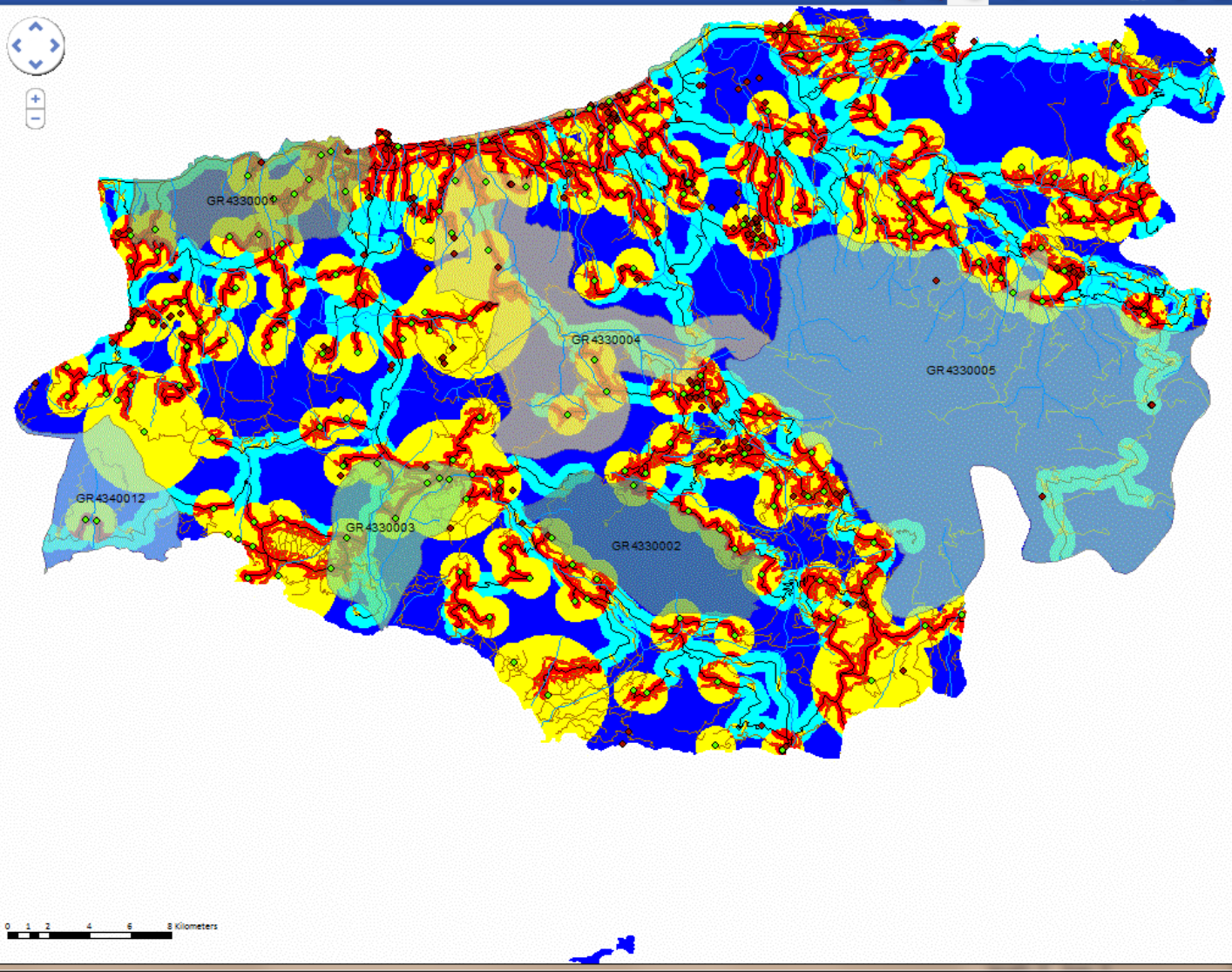

감사합니다

This work was performed in the framework of the PEFYKA project within the KRIPIS Action of the GSRT. The project is funded by Greece and the European Regional Development Fund of the European Union under the NSRF and the O.P. Competitiveness and Entrepreneurship.